VOL. XCVII FEBRUARY, 1933 No. 2

ANNALS of SURGERY

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A Monthly Review of
Surgical Science and Practice

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Official Publication of the American Surgical Association, of the New York Surgical Society and the Philadelphia Academy of Surgery

CONTENTS

Treatment of Fractures in the Cincinnati General Hospital—*John A. Caldwell, M.D., Cincinnati, Ohio,* 161

The Treatment of Joint Fractures—*Ralph Colp, M.D., Sigmund Mage, M.D., New York, N. Y.,* 177

Late Results of Separation of an Epiphysis—*Jay Ireland, M.D., Chicago, Ill.,* 189

Fractures of the Head and Neck of the Radius—*John V. Bohrer, M.D., New York, N. Y.,* 204

End-Results of Carpal-Scaphoid Fractures—*Leeman E. Snodgrass, M.D., Philadelphia, Pa.,* 209

Reconstructive Operation for Non-reducible Fractures of the Head of the Humerus—*Laurence Jones, M.D., Kansas City, Mo.,* 217

Elephantiasis Nostra—*George P. Muller, M.D., Claus G. Jordan, M.D., Philadelphia, Pa.,* 226

Intracapsular Fractures of the Neck of the Femur—*Laurence Jones, M.D., Kansas City, Mo.,* 237

Localized Tuberculosis of the Chest-Wall—*Richard H. Meade, Jr., M.D., Philadelphia, Pa.,* 247

The Full-Thickness Skin Graft—*John H. Garlock, M.D., New York, N. Y.,* 259

Transactions of the New York Surgical Society—*Stated Meeting April 27, 1932,* 274

Transactions of the Philadelphia Academy of Surgery—*Stated Meeting April 4, 1932,* 300

Brief Communications—The Overslung Traction Saddle Frame—*Earl D. McBride, M.D., Oklahoma City, Okla.* Treatment of Intracapsular Fractures of the Neck of the Femur—*Royal Whitman, M.D., New York, N. Y.* Technic for Care of Ollier-Thiersch Skin Grafts—*Daniel J. Leithauser, M.D., Detroit, Mich.* Osteoma of the Frontal Bone—*William O. Ott, M.D., Fort Worth, Texas.* A Practical Application of Wolff's Law as to the Internal Structure of Bone—*Edward H. Ochsner, M.D., Chicago, Ill.,* 309

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ANNALS *of* SURGERY

Vol. XCVII FEBRUARY, 1933 No. 2

TREATMENT OF FRACTURES IN THE CINCINNATI GENERAL HOSPITAL

By John A. Caldwell, M.D.

of Cincinnati, Ohio

From the Surgical Department of the College of Medicine of the University of Cincinnati

The fracture service of the Cincinnati General Hospital is controlled by the Department of General Surgery and is under the direction of an associate Clinical Professor of Surgery. He is assisted by the resident and assistant resident surgeons, all of whom are members of the Graduate School of Surgery. One of the latter serves on the fracture service exclusively for a period of six months, during which time he has direct supervision and care of all patients with fractures. He is assisted by an interne on each ward whose work, however, is not confined to fractures. In the absence of the director or other members of our surgical staff, this assistant resident has available for consultation the chief resident surgeon, who has previously had a term in the fracture service, as well as other assistant residents who have completed their fracture service.

This arrangement places all of the care of broken bones under one responsible head—a system which has both advantages and drawbacks but which definitely fixes responsibility. This plan, with but slight modification, has been employed for ten years. It is the purpose of this paper to describe some methods, procedures and apparatus which have gradually evolved in this period of time rather than to give tabulated series of cases and results.

Following list shows the fractures which were admitted to the hospital during one year and it may be considered fairly typical for each year. It does not include ambulatory cases which were treated in the dispensary and not admitted to the wards. The minor fractures enumerated were associated with more serious injuries which made hospitalization of the patient necessary.

Skull	255	neck	15
Mandible and maxilla	41	intertrochanteric	14
Clavicle	21	sub-trochanteric	14
Scapula	3	condyles	3
Metacarpal	6	trochanter only	2
Metatarsal	12	pathological	1
Os calcis	8	Tibia and fibula	137
Zygoma	2	Pott's fracture	20
Nasal bones	3	Patella	7
Femur-shaft—adult	36	Olecranon	10
shaft—children	23	Vertebræ	32

Ribs without serious respiratory symptoms	46	Colles fracture	40
Crushed chest	21	Dislocations	9
Pelvis	35	Multiple fractures unclassified	2
Humerus	63	Traumatic amputations	26
Radius and ulna	26	Total number of fractures	933
		Total number of patients	804

Anæsthesia.—For general anæsthesia, our preference is for ether, although gas and chloroform are occasionally used when the period of anæsthesia is to be short or there are other special indications.

For reductions alone we have become strong advocates of the use of local anæsthesia after the manner popularized by Böhler.[3] The points to be

FIG. 1.—Illustration of the usual method of treating fractures of the shaft of the femur—a Thomas splint with the Pearson attachment. The Steinman pin is inserted through the head of the tibia, but when there is special reason it is occasionally passed through the lower end of the femur.

emphasized for success in rendering the manipulation of a fracture painless by means of local anæsthesia are: (1) The anæsthetic *must* be injected into the hæmatoma surrounding the ends of the bone so as to dilute the blood with the anæsthetic solution. To make sure that this requirement will be fulfilled, the piston is drawn back and no injection is made until pure blood appears in the syringe. When the needle is in the hæmatoma the solution may be injected with very little pressure. The injection of the solution outside of the hæmatoma is certain not to relieve the pain of the fracture during manipulation. (2) It is important to wait a sufficient period of time for the anæsthetic to take effect before any manipulation is made. Our practice is to wait ten minutes *by the clock* before the fragments are moved.

Two per cent. procaine is used. For fractures of such bones as the humerus, radius or ulna, and tibia or fibula, ten cubic centimetres are usually sufficient; for the femur twenty cubic centimetres, or even forty cubic centimetres, may be necessary. These quantities are proportionately reduced in children. When there is a fracture of both bones of a limb, both fractures must be injected. Local anæsthesia has been used in about 900 fractures, and so far no infection has resulted from its use. One extremely useful application of local anæsthesia is its injection prior to transportation of a patient. This may be done in the home. The anæsthesia persists for one to two hours and thus lessens the pain and shock incident to moving the patient.

FIG. 2.—Suspension of the thigh at a right angle to the body in an oblique sub-trochanteric fracture of the femur when it is necessary to rotate the shaft of the femur outward to align it with the externally rotated upper fragment. Since the hamstring muscles are completely relaxed, the fragments may easily be pulled apart by too heavy weights.

Spinal anæsthesia is frequently employed in cases of fractures of the leg and so far there have not been any untoward sequelæ from its use. It is used in preference to local anæsthesia when it is necessary to carry out two or more painful procedures, as, for example, the manipulation of a fracture, the application of an apparatus and the insertion of a pin or ice tongs.

Brachial anæsthesia is used infrequently, and in our hands there is often a failure to secure satisfactory anæsthesia. This is possibly because we do not make use of the method often enough to become proficient in the technic of the injection.

Fractures of the Neck of the Femur and Intertrochanteric Fractures.—These fractures fall into two classes: (1) Those in which the general condi-

tion of the patients indicates the employment of ideal treatment; and (2) those in which general feebleness of the patients forbids ideal treatment.

For patients in the first class our preference is for the Whitman abduction treatment, occasionally preceded by an impaction of the fracture after the method of Cotton. Intertrochanteric fractures are often treated by Buck's extension or some form of balanced skin or skeletal traction. Several years ago we treated a series of seventeen cases of fractures of the neck of the femur by means of the Wilkie[1] spreader and were convinced that in patients so treated the fragments remain in position during all possible changes of position. The end-results were quite as satisfactory for securing union as by other methods. However, the patients were less comfortable because the

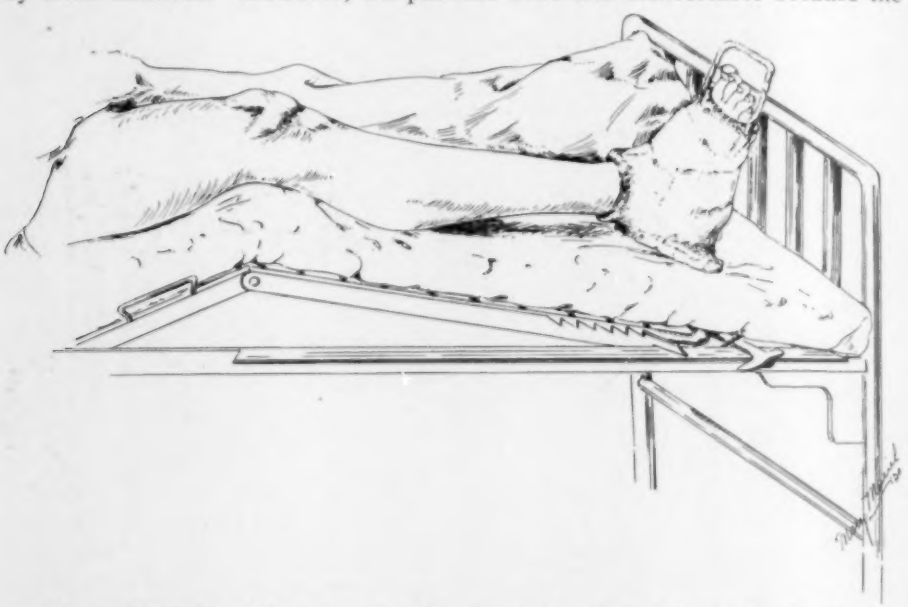

FIG. 3.—Illustration of the anti-eversion boot which is used instead of sand bags in the treatment of impacted fractures of the neck of the femur when a plaster case is inadvisable. A well-padded boot of plaster is applied and a cross bar of wood is incorporated so that the foot cannot rotate. The loop of wire extending above the toes keeps the bed clothes off the toes and obviates the troublesome bed cradle. This loop is put in all leg cases when the patient is confined to bed.

position was a straining one, and because the pressure of the plaster boots was often painful, and occasionally caused pressure sores. The nursing of the patients in spreaders was more troublesome. Since arriving at the above conclusion the Wilkie method has been reserved for these patients who, by reason of obesity or urinary incontinence, were not proper subjects on whom to apply a Whitman spica.

For patients in the second class, the treatment is modified as indicated by the general condition of the patient, and needs no special discussion. For reasons of age, general debility, pneumonia, shock, the treatment is often rest in bed with no appliances, the use of sand bags, or some simple form of extension.

Fractures of the Shaft of the Femur in Adults.—When the X-ray or

fluoroscopical examination shows that the fracture is transverse and the chances of reduction favorable, we inject local anæsthesia, apply a Thomas splint and attempt to engage the fragments. If successful, the leg is laced firmly in the splint and left until the fragments are stuck by provisional callus. A spica of plaster is then applied. The proportion of successes in this form of treatment is not high. It must be remembered that fractures thus treated may slip and that frequent checks of the position of the fragments must be made by X-ray studies. When unsuccessful in maintaining reduction the leg is suspended under a Balkan frame in a Thomas splint. After accurately counterbalancing it and flexing the knee, traction is made by means of a Steinman pin through the head of the tibia. (Fig. 1.) We prefer

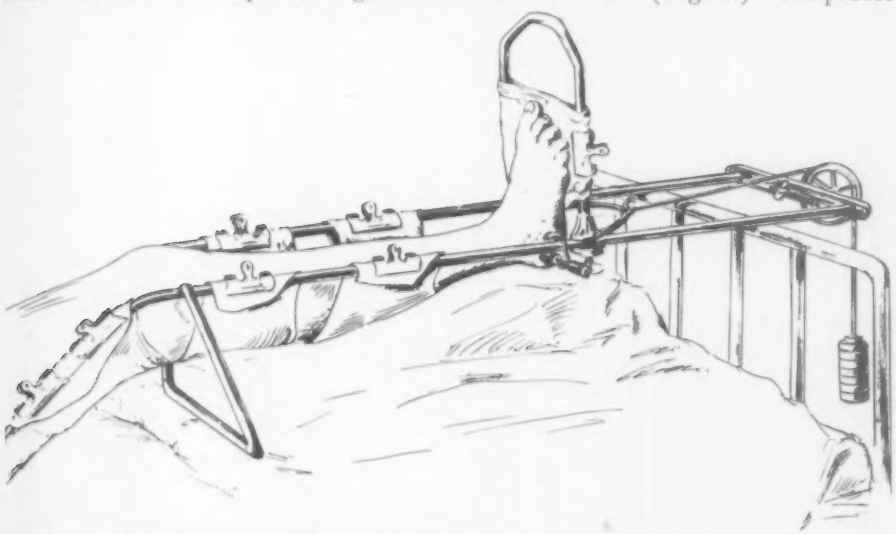

FIG. 4.—A simpler device which serves the purpose of the more cumbersome and expensive Braun frame. It is used for fractures of the tibia and fibula when traction is necessary. The pull is usually made on a pin through the os calcis, occasionally on ice tongs in the malleoli. By attaching another "croquet wicket" over the thigh this splint may be used as a Hodgen's suspension splint. (See also Fig. 10.)

to insert the pin through the tibia rather than above the femoral condyles, for we believe there is less danger of infecting the knee-joint or the fracture. Also, if traction is not successful and an open operation becomes necessary, the operative procedure does not have to be postponed or abandoned because of pin punctures near the field of operation. Occasionally, when the fracture is low in the femur, the pin must be inserted above the femoral condyles to correct the position of the lower fragment. In our experience with this fracture, it is just as well to perform an open operation early since it is inevitable in most instances.

One of the most troublesome fractures of the femur to treat is the oblique or comminuted sub-trochanteric break. We have had excellent results with a method of suspension and traction which we have not seen described elsewhere. A pin is inserted above the femoral condyle and the thigh is suspended at a right angle to the body, much as it is suspended in the Bryant method used for children. The knee is flexed to a right angle and the leg

is suspended by a sling to a different rail, and counterbalanced by a separate set of weights. By this apparatus the thigh can be rotated outward until the distal fragment comes into line with the externally rotated and flexed proximal fragment. With this arrangement the entire limb is suspended and counterbalanced; the patient's body makes the counter-traction. He can shift or raise his body without disturbing the fragments. There is great danger in this method of pulling the fragments apart and seriously delaying union. In this flexed position of the leg, the hamstring muscles are quite relaxed and offer very little resistance to traction. We do not hesitate to use thirty or thirty-five pounds' pull on the ordinary fracture of the femur when the knee

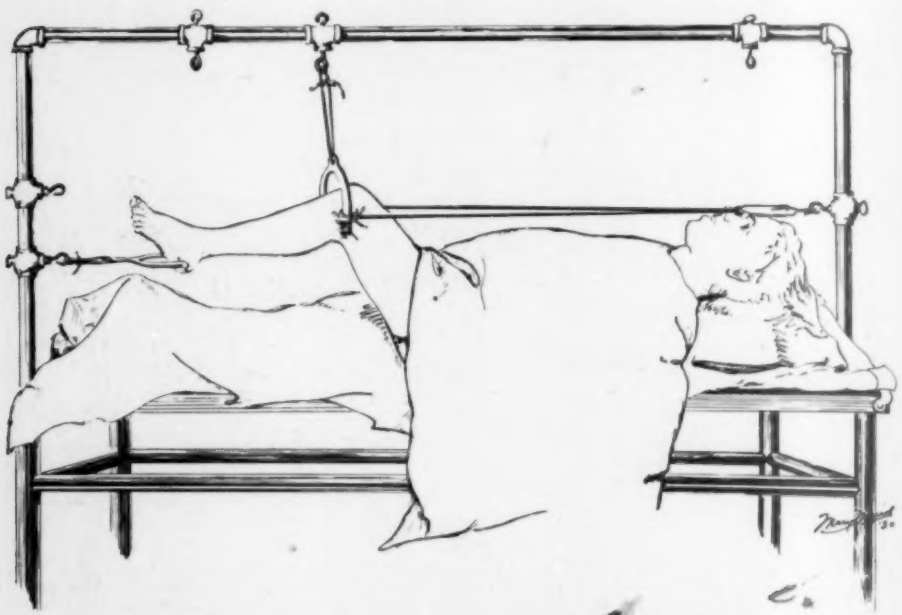

FIG. 5.—The leg is suspended in traction by an overhead rail attached to the fluoroscopical table and is ready for the application of a case. The suspension and traction are upon pins or ice tongs which are removed as soon as the plaster is "set."

is semi-flexed, but, in the above method, when both thigh and knee are flexed to right angles, we ordinarily do not use more than fifteen to eighteen pounds. Even then the position of the fragments must frequently be checked with portable X-ray films. (Fig. 2.)

Fractures of the Femur in Children are suspended at a right angle after the manner of Bryant[2] in all suitable cases. If the uninjured thigh can be flexed to a right angle with the body without causing the knee to flex, the case is regarded as a proper one in which to carry out this method. In our experience this procedure can be used up to nine years, after which age children must be treated as are adults. Studies of end-results in our own patients, as well as others, have shown that good function results in these fractures in children in spite of extraordinary malposition of fragments. X-ray studies and measurements two or three years after union show almost unbelievable restitution of both length and contour.

Open operations are performed in those fractures of the femur in which end-to-end approximation (not necessarily of the entire fractured surface) cannot be secured, or when interposition of muscle makes approximation impossible by closed methods. An endeavor is made to arrive at a decision concerning operation at the earliest possible moment. So far it has not been necessary to operate on the femur of a child under sixteen years of age. When open fixation is necessary our preference is for the Sherman plate and screws, although occasionally, when the break is very oblique, a Parham-Martin band is applied. The band is particularly suitable when the fracture is near the knee-joint. In this situation a plate is not satisfactory since the

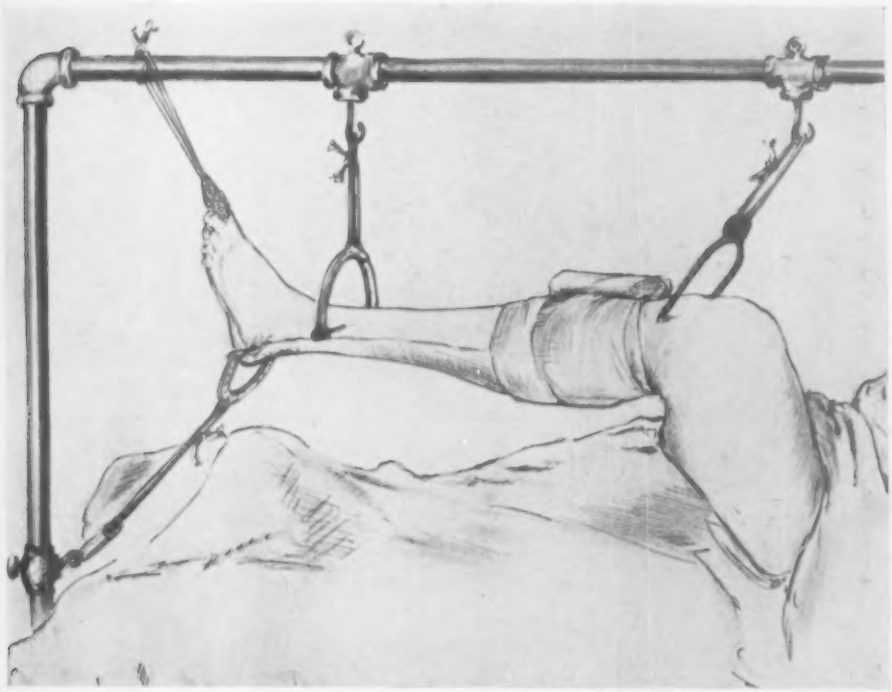

FIG. 6.—A fracture of the os calcis is suspended and pulled into position after the fragments have been squeezed into place by the redresseur and is ready for the application of plaster. The pin and tongs are removed after the plaster is "set." Instead of the ice tongue or a pin below the knee a sling may be used about the thigh for counter-traction.

lower fragment is cancellous bone and screws do not hold well, and, if the break is very low, that portion of the plate which is applied to the lower fragment may be within the knee-joint, or at least may necessitate opening the knee-joint to apply it. After operation a plaster case is applied, or the leg is returned to the Thomas splint and suspended as before operation.

The Patella.—In fractures of the patella without separation of fragments, and when the power to extend the knee is retained, a Schanz dressing*

* I have been unable to find a description of the original Schanz dressing. The dressing to which we apply the name *Schanz* is as follows: The leg is wrapped from ankle to mid-thigh with two layers of sheet wadding, such as is used under a plaster bandage,—with as much tension as the texture of the material will allow. This is covered with

is applied for one week and the joint is aspirated whenever it becomes distended with blood. After one week a case is applied with the leg extended and the patient is allowed up on crutches. When the X-ray shows the fragments separated and the power of extension of the knee is lost, the case is considered as an emergency and an operation is done at once. The capsule of the patella is closed with mattress sutures of catgut, and the patella is surrounded with a loop of the same material. All shreds are carefully cut off, and the rents in the lateral expansions of the quadriceps tendon are accurately closed. A plaster bandage is then applied with the leg in extension. The operating is done through a transverse incision. Only one infection has followed an operation on the patella, and that was one in the case of an extensive compounded fracture.

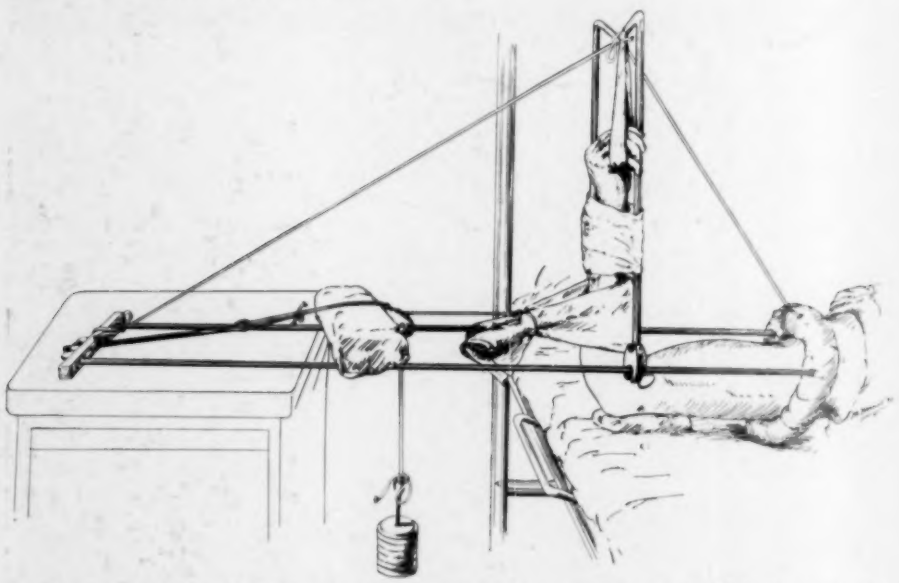

FIG. 7.—A method of applying traction in cases of fracture of the neck of the humerus. The traction is made with a Thomas knee splint and a Pearson attachment. The pull may be made upon a pin through the olecranon or a wire through the condyles instead of a sling about the forearm.

Fractures of the Tibia and Fibula.—An injury which has been encountered quite frequently has been called the "bumper fracture." The victim sustains a blow by an automobile bumper on the outer side of the knee, which causes a comminuted crushing fracture of the head of the fibula and the outer condyle of the tibia. The force of the impact bends the knee laterally, tearing or stretching the internal lateral ligament. The knee-joint immediately distends with blood, and on manipulation lateral motion is marked. These injuries are treated by the application of a dressing and aspiration of the knee-joint, followed by a plaster case which is worn for six weeks. In two

turns of muslin bandage drawn quite tight. Two more layers of sheet wadding are then applied over the muslin bandage and a second muslin bandage is applied firmly over this second layer of sheet wadding. This makes a dressing which exerts uniform pressure over the surface and, on account of its bulk and stiffness, has considerable immobilizing effect.

cases where the outer condyle had been greatly displaced, it was replaced by an open operation and held in place by a bolt through the head of the tibia. Weight-bearing is forbidden for six weeks after removal of the case. There has been no case of serious restriction of range of motion of the knee-joint from this prolonged fixation, but in three cases we have seen a more serious sequel. Because of impaired blood supply, or some other reason, the damaged condyle in these cases was gradually eroded and the opposing condyle of the femur was deprived of a bearing surface; the weight was then thrown

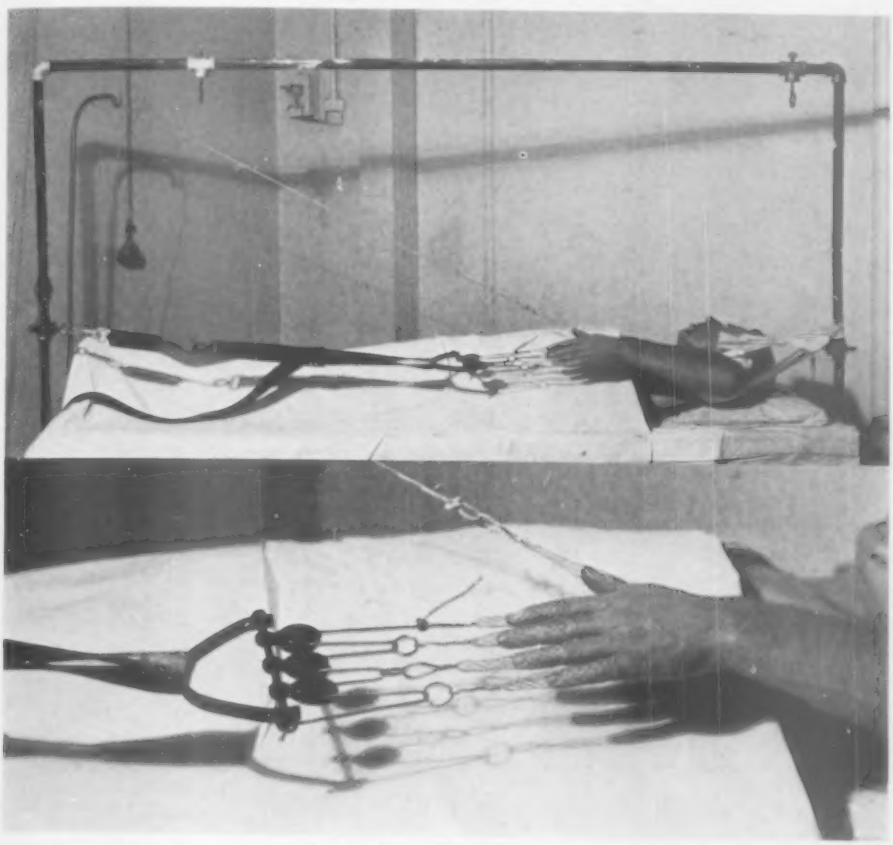

FIG. 8.—The forearm is suspended and pulled by means of "finger traps," and is ready for the application of plaster. This apparatus is used in fractures of the radius and ulna and Colles fracture.

entirely on the inner condyle. As a result a gradually increasing genu valgum was produced which finally required the patients to use braces. We know of no way of avoiding this complication except by prolonged restriction of motion and abstinence from weight-bearing.

Fractures of the shaft of the tibia and fibula, when transverse, are reduced under local or spinal anæsthesia and then fixed in plaster at once. (Fig. 5.) Any leg which is wholly encased is elevated at least 30°. The case is promptly removed if the toes show any impairment of circulation. When reduction

is accurate early swelling is apt to subside rather than progress although this is not universally true.

Pott's fractures are usually reduced under spinal or general anæsthesia and a circular plaster bandage or Stimson's dressing is applied at once. This fracture is put up in the position of ease and rest—that is, the foot is neither everted nor inverted and is at little more than a right angle with the leg. Occasionally the break is of such type that strong inversion is necessary to maintain position and, in such cases, the foot is placed in the inverted position but is changed to the more normal and comfortable position in ten to

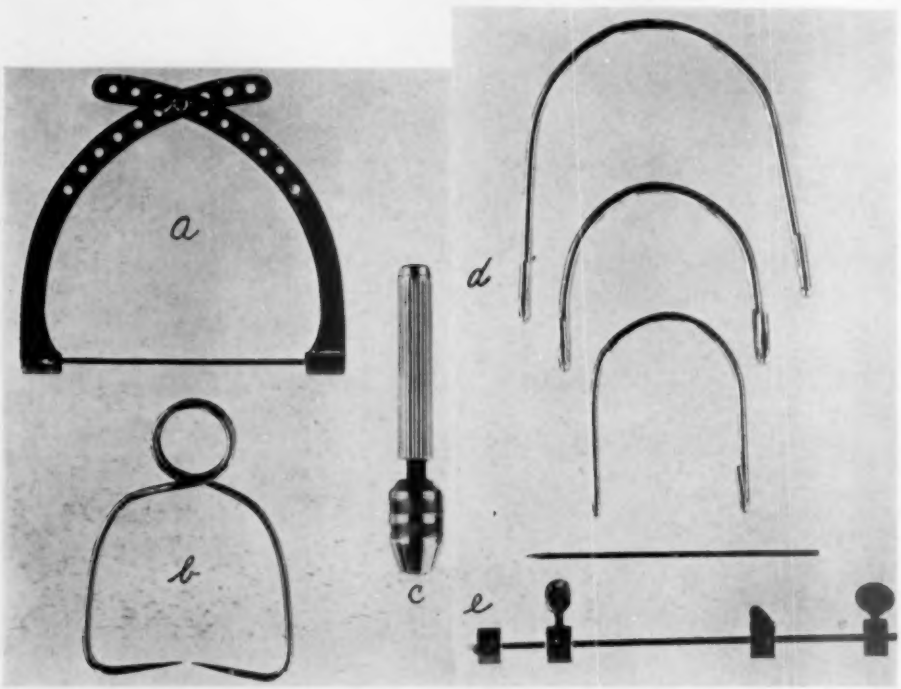

FIG. 9.—The usual contrivances used for skeletal traction. (*a*)—Classical holder for the Steinman pin. This type is made of an aluminum alloy which is much lighter than steel and does not require replating. (*b*)—Type of ice tongs. These are but rarely employed and then only for temporary use. (*c*)—Hand chuck for inserting the Steinman pin. With this device a pin may easily be inserted through cancellous bone. When it is necessary to thrust it through cortical bone, a breast drill is used. (*d*)—Steel loops which are attached to Steinman pins. They are made of 5/16 inch steel. It is desirable to have the pin turn in the holder rather than in the bone; skin infections at the point of puncture are less frequent when the pin is stationary in the bone. (*e*)—Steel pins used for skeletal traction. The smaller is 3/32 inch in diameter and 6 inches long. It is used in the olecranon, condyles of the humerus, and in the legs of children. The larger pin is 5/32 inch in diameter and 9 inches long. These are made of stainless steel and are not tempered hard. The collars are to prevent the pin from slipping off the splint bars and are made of aluminum bar ½ inch in diameter.

fourteen days. We have used the unpadded plaster case and the walking iron as advocated by Böhler.[3] In our experience it works when the patient is coöperative and sufficiently ambitious for early restoration to stand some discomfort. We have no special fear of unpadded plaster cases when the plaster bandages are applied smoothly and the part is elevated and watched until a safe period has arrived. A rule to be observed in applying plaster directly to the skin is to place the first layers in a longitudinal direction and

usually as plaster splints. These are then covered with encircling turns. By this method the case can be applied directly to the skin with little danger of the formation of constricting ridges.

Fractures of the tibia and fibula which by reason of comminution or obliquity of the fragments cannot be reduced are placed in traction by means of a pin through the os calcis. The leg is held in a splint which we have devised, with the knee in a slightly flexed position. This splint answers the same purpose as the Braun frame advocated by Böhler,[3] but is much less expensive and does not interfere with the nursing care of the patient to the same extent as does this frame. (Fig. 4.) The Thomas splint was formerly used in the same manner, but this does not permit the flexion of the knee, and the perineal counter-pressure is highly objectionable when continued for considerable time, particularly in women.

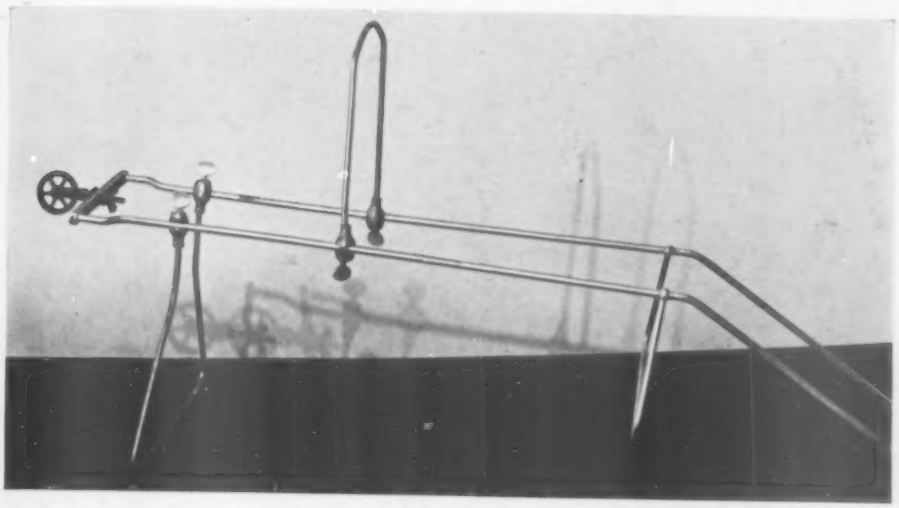

FIG. 10.—A splint used in fractures of the tibia and fibula when traction and elevation are desirable. Another "croquet wicket" may be attached and the entire apparatus may be suspended under a Balkan frame.

Fractures of the Os Calcis.—The plan described by Böhler[3] is used. Instead of the frame described by him we have used one which has been attached to the fluoroscopical table and which is ordinarily used for making traction on the forearm. (Fig. 6.) The steps are as follows: Spinal or general anæsthesia is administered. A pin is inserted through the tibia a hand's breadth above the ankle-joint, and another is passed through the os calcis. The leg is suspended by the pin through the tibia with the knee flexed to an angle of 120°. Traction is made downward and in the long axis of the leg by the pin through the os calcis and counter traction is made by a sling about the lower end of the thigh. The spread fragments of the os calcis are then squeezed back to the thickness of the other os calcis by means of the Böhler redresseur clamp. After this a case of plaster applied direct to the skin covers the leg to the knee. The pins are removed as soon as the plaster has hardened completely.

Head Injuries.—Scalp wounds are immediately débrided and explored. Stereoscopical X-ray films are taken with the injured side down, as soon as the patient's condition permits. If the patient is in shock, the examination is limited to that which can be made with a minimum exposure of the patient. If the patient is not in shock a complete neurological examination is made and the findings recorded. If the pulse is slow, consciousness blunted, or focal symptoms are present, a spinal puncture under local anæsthesia is made, always measuring the pressure of the cerebrospinal fluid and noting the

FIG. 11.—A method of treating some fractures of the humerus. The weight of the plaster case makes traction on the lower fragment and to some extent stabilizes the arm. The sling is passed through the wire ring instead of around the forearm where it readily slips.

degree of intracranial bleeding. This pressure is measured by a simple type of manometer which registers the rise of the spinal fluid in a glass tube. The routine nursing observation includes half-hourly records of the pulse and respiration, and notification of the physician if the pulse rises above 100 or falls below 60 and if the respirations become unusual. Blood-pressure readings are made frequently. If the spinal-fluid pressure is above twenty centimetres fluid is withdrawn till it is fifteen centimetres or lower. If the pressure is extremely high—thirty-five centimetres or more—withdrawal is made cautiously and slowly and the pressure is not reduced below twenty centimetres. A spinal puncture is repeated as often as three times a day

when a high pressure is sustained. The head of the bed is elevated, and fifty cubic centimetres of 40 per cent. glucose are given intravenously every eight hours while the pressure remains high. The total intake of fluids is restricted to 2,000 cubic centimetres during twenty-four hours.

More than 4,000 spinal punctures have been made and there has not occurred a sudden death due to herniation of the medulla through the foramen magnum. In the past two years fewer decompressions have been made for sustained high intracranial pressure. We have depended almost entirely on chemical shrinkage of the brain or repeated spinal punctures for reduction of the pressure.

Our treatment corresponds closely to that described by Temple Fay,[4] Dowman,[5] and Kennedy and Wortis,[6] in recent reports. The following types are operated upon: (1) Extradural hæmorrhage; (2) depressed fractures; (3) fractures associated with focal symptoms indicating lacerations of the cortex, localized intradural bleeding, or intradural accumulations of cerebrospinal fluid due to the fluid escaping through rents in the arachnoid.

Fractures of the Pelvis.—When accompanied by laceration of the bladder or urethra, the visceral complication is given attention by the members of the urological service. When there is no visceral complication and the fracture is not grossly displaced, the treatment is rest in bed on a springless mattress for six to eight weeks. This treatment is employed when the patient can lie comfortably and not have pain during the shifting occasioned by ordinary nursing care. When slight movement causes pain a body plaster case is applied from axilla to knees. The legs are slightly abducted and the thighs are flexed to about ten degrees. In two instances separation of the pubis has been restored to a suitable degree by a tight swathe. In two other cases the patient has been suspended by a swathe about the pelvis. The suspending straps are crossed above the patient's body so that the lateral compressing force of the swathe is increased. Three cases have required open operation and fixation. The result has been great improvement of position, but no perfect restoration.

Central Dislocations of the Femur.—In the past year there have been two complete central dislocations of the head of the femur, which have been replaced by manipulation. In each case the manœuvre was as follows: The patient was fixed in bed by a swathe about the body, fastened to the bed rail on the side of the body opposite the injury. One assistant made lateral traction by a band about the upper thigh; a second assistant pulled in the long axis of the leg, while a third person attempted to aid by pressure on the head of the femur with a finger in the rectum. In both cases the finger in the rectum could feel the head slip out when the pull was exerted. The replacement did not require the exercise of great force. In one case the position was maintained by a spica plaster case and in the other a large screw eye was screwed into the trochanter and lateral traction was made. This patient had had a guillotine amputation below the knee which required dressing which made a plaster case not feasible.

Fractures of the Spine.—When the condition of the patient permits, fractures in the cervical region are manipulated under anæsthesia. The manœuvres of Walton[7] and Langworthy[8] have been used. After this manipulation, traction on the head is maintained for six weeks. This is followed by fixation of the neck for three months by a helmet and body plaster case, or the Thomas collar. In some cases success in effecting a complete replacement has been obtained. In others the position was only moderately improved. In no case has the manipulation been followed by cord or root symptoms.

Crushed fractures of the bodies of the thoracic and lumbar vertebræ are treated by the procedure of Davis,[9] and a plaster case is supplied with the body hyper-extended. The case is worn for eight to twelve weeks. After removal of the case a Taylor brace is fitted and is worn until the patient has no discomfort. In several cases the spine has been fused by an Albee bone graft. This was done when fixation of the vertebræ was inevitably necessary and when prolonged use of a brace was not compatible with the patient's following his occupation. We have not had enough experience with this operative procedure to enable us to give any definite judgment as to its merit. Two patients are definitely unimproved, and have been unable to resume work after two years. Several others have resumed work of lesser stress. As with many other injuries entailing possible prolonged discomfort, the question of compensation introduces a variable which makes for considerable uncertainty of prognosis.

Fractures of the Humerus.—In the case of fractures of the neck and epiphyseal separation, with impaction and good position, our uniform plan is to immobilize the arm by a swathe about the body and to hang the forearm by the wrist in a sling. Motion of the forearm is begun early—gentle swinging at first, gradually increasing to full motion. Our plan follows closely that described by Roberts.[10] When the position is not satisfactory treatment has been by traction at a right angle with the forearm flexed. (Fig. 7.) Manipulation has usually been unsuccessful, because the head cannot be sufficiently fixed by grasping through the deltoid mass while the long distal fragment is manipulated. In our experience the cumbersome plaster bandaging holding the arm abducted or the aeroplane splints are quite unnecessary in the ordinary case.

Fractures of the shaft of the humerus are treated by reduction and application of a plaster bandage from wrist to axilla with the forearm flexed to a right angle. (Fig. 11.) A ring of wire is incorporated in the upper side of the cast at the wrist and through this the suspending sling is threaded. This treatment does not furnish immobilization, but it does restrict motion. The weight of the cast applies traction while the patient is standing or sitting. The sling is passed through the ring rather than about the forearm because, when in the former place, the sling cannot slide up toward the elbow and vary the traction. When a fracture is transverse and can be reduced it is usually fixed firmly to a triangle interposed between the arm and body; the arm and forearm are immobilized with plaster. This method of fixation is changed to

the less cumbersome method described above as soon as provisional callus has fixed the fragments so that they will not be displaced by slight motion.

Fractures of the humerus about the elbow-joint are treated by reduction and fixation in acute flexion which is maintained by the gage halter of Hugh Owen Thomas or an Ashhurst dressing.* If swelling of the arm prevents this the arm is sharply elevated by an inclined plane or suspension, and later reduced and fixed, as described, when the swelling permits. In our own cases there have been no instances of Volkmann's contracture. This position of acute flexion is maintained for four weeks; then the forearm is placed in a sling at a right angle for two weeks. Early passive motion is not used. No case has failed to recover complete flexion, though several cases have recovered extension to only 135° at the last observations. However, these were cases in which accurate reduction was not obtained.

Fractures of the Ulna and Radius.—Colles' fractures and fractures of the radius and ulna are reduced under the fluoroscope after "finger traps," with interposed spring balances, have been applied to the fingers and thumb.[11] (Fig. 8.) Counter-traction is made with a sling about the arm just above the elbow, and the traction straps are tightened until the spring balances register fifteen to twenty pounds. The anæsthesia is usually novocaine. After a few minutes' traction the fragments are reduced by manipulation. In Colles' fractures a plaster case is applied directly to the skin from the elbow to the fingers. This case is worn for four weeks during which period active use of the fingers is encouraged. When the fracture is higher in the forearm, or involves both bones, one-half-inch dowel sticks are pressed into the plaster splints opposite the interosseous space and are held in place by encircling turns of plaster. This bandage remains in place for six weeks.

Fractures of the olecranon, with separation of fragments and impaired power of extension, are considered frank cases for an open emergency operation. The fragments are usually fixed with wire which passes through the shaft of the ulna and through the triceps tendon just above the upper fragment. After this operation no fixation is applied to the elbow, the arm is simply hung in a sling at a right angle. In fractures of the olecranon without separation of fragments and no impairment of extension no dressing except a sling is employed. Fractures of the olecranon are never fixed in extension. No cases of infection have followed immediate open operations on fractures of the olecranon when the fracture was not compound. There was one infection in a compound fracture.

In cases of fractures of the head and neck of the radius, with much displacement of the fragment, immediate removal of the head seems to be the

* *Ashhurst Dressing.*—This is a position of hyperflexion with the hand as near the shoulder as it can be brought and not across the chest. The fixation is obtained by means of a bandage which commences at the wrist, the end being left long. It then is wound around the upper arm and the elbow with circular turns, the latter being fixed with vertical turns. The dressing is completed by tying the ends of the bandage at the wrist, then knotting them around the neck.

procedure of choice. Non-operative measures, in a few cases where the head was split and the fragments slightly displaced, were frequently followed by abolition of the power of pronation and supination.

Fractures of the Ribs.—In crushed fractures of the chest with multiple fractures of the ribs our procedure is as follows: (1) The patient is propped up in bed in the position in which he breathes most comfortably; (2) the chest is strapped; (3) the patient is put under an oxygen tent at once. The early and prolonged use of oxygen seems to be of paramount importance; (4) morphine is given liberally; (5) air or blood in the chest is aspirated as indicated. If possible, this is not done until after three or four days, in order to allow the points of escape of blood and air to become closed.

SUMMARY

(1) The organization and the procedures for the treatment of fractures in the Cincinnati General Hospital are described.

(2) A large variety of fractures are admitted to the hospital each year. A summary of the different types admitted in one year is given.

(3) There is a brief consideration, with illustrations, of our present methods of treating these various types of fractures.

(4) Practically all of the illustrations are modifications of classical apparatus which have been changed in form, but not in principle, to meet our requirements of economy and a more or less standardized method of handling large numbers of fractures. Almost no commercial splints are used because the quantity and variety necessary could not be afforded, and, also, because it is desirable that the numbers of the house staff shall come to depend on their own resources. Most of the apparatus is made in the mechanical shops of the hospital.

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THE TREATMENT OF JOINT FRACTURES

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Fractures involving joints present an important surgical problem because the compromise of joint function may lead to serious disability. It is only through a thorough understanding of the various factors underlying their proper treatment that the end-results, which are so often unsatisfactory, may be improved. It was with this purpose that a study of joint fractures was undertaken, and it is the object of this communication to emphasize the experiences gained in the treatment of this type of injury.

Table I

Anatomical Distribution of Fractures into Joints

Upper Extremity			Lower Extremity		
	Bone	No.		Bone	No.
	Scapula	5		Acetabular cavity	4
	Humerus—upper extremity	2		Femur—upper extremity	6
	Humerus—lower extremity	6		Femur—lower extremity	4
	Ulna—upper extremity	6		Patella	29
	Radius—upper extremity	8		Tibia—upper extremity	5
	Radius—lower extremity	12		Tibia and fibula—lower extremity	24
Carpus	Scaphoid	10			
	Os magnum	1	Tarsus	Os calcis	19
	Semilunar	1		Cuboid	3
	Navicular	1		Scaphoid	4
				Navicular	2
				Astragalus	2
		52			102

Fractures into joints are not as common as those of the long bones. One hundred fifty-four fractures involving joints exclusive of the spine were admitted to the surgical wards of the Beekman Street Hospital from 1926 to 1930 (Table I), during which time the total number of fractures treated

Table II

Distribution of Joint Fractures

Upper Extremity Fractures			Lower Extremity Fractures		
Shoulder-joint	7—13.5%		Hip-joint	10—10%	
Elbow-joint	20—38.5%	52—33%	Knee-joint	38—37%	102—67%
Wrist-joint	25—48.0%		Ankle-joint	54—53%	

was 2,250. Joints adequately protected by large muscles such as the hip and shoulder are not as liable to injury as those guarded mainly by tendinous structures such as the wrist and ankle. (Table II.) Joints of the lower extremity, hampered by weight-bearing, are more prone to injury than those of the upper, in which the conditioned reflexes are quicker and more adept in protective movements. Moreover, the range of evasive motion of the entire upper extremity is enhanced by the great mobility of the shoulder-joint.

This group of fractures rarely shows much displacement, and the alignment of the bone fragment is usually good. Localized direct violence, which plays the foremost rôle in the mechanism of these injuries, should tend to produce comminution with separation of bone fragments. Great displacement, however, is prevented by a dense fibrous joint capsule reinforced by surrounding ligaments. In such joints as the hip and knee, the intra-articular ligaments have an additional stabilizing and immobilizing influence.

TABLE III

Association of Other Fractures with Fractures into Joints

Upper Extremity—31%	Cases
Fractures into glenoid of scapula associated with other fractures	3
Fractures of the humerus—upper end	1
Fractures of the humerus—lower end	0
Fractures of the ulna—upper end	1
Fractures of the radius—upper end	2
Fractures of the radius—lower end	4
Fractures of the carpus	5

Lower Extremity—25%	Cases
Fractures into acetabular cavity associated with other fractures	2
Fractures of the neck of the femur	0
Fractures of the lower extremity of the femur	0
Fractures of the patella	4
Fractures of the tibia—upper end	3
Fractures of the tibia and fibula—lower end	8
Fractures of the tarsus	8

While a study of Table III indicated that 26.5 per cent. of joint fractures are associated with fractures of other bones, a glance at Table IV shows that less than 1 per cent. present evidences of compounding. This low incidence of soft part injury may be due to the protective influence of the overlying clothing and the small displacement of fragments which makes the projecting bone improbable.

TABLE IV

Presence of Compounding in Fractures into Joints

Patella fractures	2	0.65%
Tibia and fibula—lower end	3	
Tarsus	1	
Humerus—lower end	1	
Radius—lower end	1	

The treatment of the associated compounding is similar to that usually employed in any contaminated accidental wound. Tetanus antitoxin is given routinely, and if a gas-bacillus infection is a possibility, a prophylactic dose of the immunizing serum is injected. The wounds are thoroughly irrigated and carefully débrided. Wounds of the upper extremity are then sutured in layers without drainage. Wounds of the lower extremity, however, are left open and packed with gauze, only the underlying joint capsule being closed. This latter precaution has been found necessary because of the greater incidence of anaërobic infections encountered in the lower limb injuries. If infection should intervene in any sutured wound, it is immediately opened, and if a suppurative arthritis is present, the joint is properly and adequately drained and the Willem's treatment instituted if feasible.

The physical signs of joint fractures and the importance of röntgenological studies have already been fully emphasized by others, but the therapy of these cases requires a more careful study. There are several basic principles of treatment which must aim to combat the factors making for a poor result. Actual intrinsic joint injury resulting in a definite irregularity of the joint surface interferes with function. Every attempt, therefore, should be made to establish normal alignment of the joint surface if the displacement warrants. Reduction may be accomplished by manual manipulation under anæsthesia, by the slower process of traction, or by open operation. Fortunately, the displacement of fragments in most joint fractures is not marked. The possibility of exuberant callus protruding into a joint cavity, while it is a conceivable complication, has never been noticed in this series, and it is slight, for it has been definitely shown that synovial fluid acts as a deterrent to callus formation. The compromise of extra-articular and peri-articular tissues, which may result in fibrous connective-tissue adhesions and contractures restricting the range of joint motion, is a serious complication which may be prevented by effective treatment. This may be partially accomplished by the immediate application of radiant heat and gentle massage whenever feasible, aided as soon as possible by early active motion within normal limits. These measures effectively prevent the organization of intra-articular blood and extra-articular exudates, maintain muscle tone, and thus reduce the possibility of adhesions within and contractures about the fractured joint. Physiotherapy, to be effective, must be employed early, not late in a vain endeavor to undo the results of poor surgical treatment. It should always be given by a competent physiotherapist under direct surgical supervision.

As a rule, active motion need not be delayed because of the fear of increasing deformity, for the original displacement of fragments is usually small and is rarely made worse by manipulation. It is only the exceptional case complicated by unusual comminution and marked separation of the fragments which is aggravated by early motion. The production of an arthritis through early motion is more likely to be theoretical than real unless there is an underlying arthritic tendency. While early motion is emphasized in obtaining a good functional result, weight-bearing should be deferred until union is

firm, for the direct pressure may cause a splaying of the bones comprised in the injured joint.

However, there are types of joint fractures in which immobilization is to be preferred to early motion. Fractures complicated by a severe compromise of ligamentous and capsular attachments resulting in dislocations do better if motion is delayed until the ligamentous injuries have been firmly healed. In these instances the application of traction to maintain reduction may permit the institution of motion at an earlier period without the disturbance of fragments. Immobilization is also preferable to active motion in arthrodial joints, for the constant slight play of the fragments in a relatively staple joint tends toward non-union, arthritis and persistent pain. But none of these measures precludes the use of immediate heat and gentle massage.

Then there are the unusual joint fractures in which the fragments become so displaced that function is interfered with by malunion, by non-union, or by small fragments lying free in the joint. These are usually best treated by operative measures. These displaced fragments may be replaced and held by suture or metal appliances. If the fragments are small they may be removed, unless this would interfere with joint function or bony growth. Severe ligamentous damage resulting in a wide separation of bone fragments or a marked subluxation of the joint may require immediate repair. The same basic principles of treatment in joint fractures already outlined should follow all operative procedures.

While these general principles form a basis for the treatment, they cannot be used routinely. Each case must be judged on the individual physical findings. In order to clarify certain special features, each group of joint fractures will be considered in detail.

Fractures of the Scapula.—The majority of fractures involving the joints of the upper extremity are of an ambulatory nature, and as a rule are treated in the out-patient department. This may account for the relatively small series of certain groups of fractures treated in the wards.

There were five fractures of the scapula involving the glenoid fossa. Two of these were associated with fractures of the clavicle and were, therefore, treated by immobilization with a Sayre dressing. The others were treated by heat and massage and active motion as soon as the condition of the patient warranted. Two cases were seen subsequently, one at the end of six weeks, and the other at the end of four months, both having satisfactory results.

Fractures of the Upper Extremity of the Humerus.—Fractures of the humerus entering the shoulder-joint are exceedingly rare because of the peculiar anatomical formation of the head and its relationship to the capsular ligament. There were two cases of this type, one complicated by an impacted fracture of the surgical neck, and the other by a readily reducible subcoracoid dislocation. Both were treated by immediate active and passive motion, heat and massage. The patients, when examined a year later, had perfect end-results, one returning to work ten weeks after injury.

Fractures of the Lower End of the Humerus.—These injuries, which

occur most frequently in children and adolescents, are more often seen in institutions serving residential areas. They were comparatively rare in this clinic. The treatment of simple fractures, without displacement extending into the joint through one or the other condyle, consists of an adhesive or bandage dressing immobilizing the elbow in acute flexion. Active and passive motion under the direct supervision of the attending surgeon is started within a week and is continued daily. The retentive dressing in these simple cases is discarded in fourteen to seventeen days. T-shaped intercondylar fractures with separation of the fragments may necessitate open operation with fixation of the fragments, and displaced or rotated condyles should be replaced. If chip fractures are present and lie free in the joint, removal of the foreign body is indicated. If closed reduction, however, is satisfactory, motion at the elbow should be delayed until sufficient union of the fragments has taken place to prevent displacement. The retentive dressing is routinely discarded by the seventeenth to the twenty-first day. The responsibility of the after-care must be taken personally by the surgeon and should not be intrusted to the physiotherapist until the danger of displacement of fragments has passed.

Six cases constitute this group, one of the external condyle, three of the internal condyle, one of the trochlea, and one of the capitellum. Reduction under anæsthesia was necessary in one case, and all were treated by acute flexion at the elbow-joint. Radiant heat, massage, and active motion were started at the end of one week. One child was operated on seven weeks after injury because of marked limitation of flexion and extension due to an external condyle which was rotated and displaced. This deformity was corrected and the condyle sutured to the humerus. The subsequent result was good.

Fractures of the Upper End of the Ulna.—The principles of treatment are quite similar to patella fractures. If the separation of the olecranon fragments is small, the treatment is conservative; if large, open operation is indicated, with active motion at the end of a week. The olecranon itself should be sutured, for the suture of the triceps tendon alone is usually inadequate to maintain the fragments in apposition. The elbow is partially immobilized at a right angle by means of a posterior molded splint, and active motion is delayed until the twelfth day.

There were six cases of this variety, three being treated conservatively and three by operation. In the former group, the elbow was supported in a sling, and physiotherapy was started within three days after injury. In the operative group, the results were satisfactory, except in one case which was complicated by a compound dislocation of the ulna and a fracture of the head of the radius. The dislocated ulna was reduced immediately, and eleven days later the head of the radius was removed and the olecranon was sutured with chromicgut. Motion was started on the third day after operation, with an unfortunate rupture of the chromic sutures. This was further complicated by an infection which eventually resulted in an ankylosis of the elbow. In the future, it might be advisable in cases of this nature to employ fascial sutures to withstand the tension of early motion.

Fractures Involving the Upper End of the Radius.—There were eight cases of this nature. The treatment depends upon the type of fracture, the location and the degree of separation of the fragments. It is felt that the only cases which should be treated conservatively are those in which the fracture is incomplete. Cases in which there is displacement respond better to open operation. Some feel that removal of the displaced fragment is all that is necessary. If, however, on pronation, the fractured portion of the radial head comes into direct contact with the lesser sigmoid notch of the ulna, only further trouble can be anticipated from this procedure. The operation of choice is the complete removal of the radial head, which is a simple procedure. This is followed by active motion within twenty-four hours. The results obtained have been excellent. One case was treated conservatively, seven were operated, the head being removed in six and the fragment in one. Six were followed, and all had good results.

Fractures of the Lower End of the Radius.—The fundamental principle of early motion applies most strongly in fractures of the lower end of the radius extending into the wrist-joint. The potential impairment of function resulting from these injuries may compromise the skilled function of the hand and the muscular power of the entire extremity. The actual management of these fractures is dependent on the specific pathology encountered. Simple fractures extending through the articular surface without impaction and displacement of the fragments are started immediately on motion, heat and massage. A volar splint of plaster may be used for a few days merely for reasons of comfort.

Those fractures with displacement, impaction, or comminution should be reduced as early as possible, striving for the best anatomical restoration, especially of the inferior radio-ulnar articulation. A volar molded plaster splint extending from the elbow to the metacarpal phalangeal joint is applied with the wrist in moderate flexion and ulnar deviation. Heat and massage are started within twenty-four hours, and active motion of the fingers and wrists in two to three days.

If the comminution has been severe and the danger of displacement is imminent, motion is delayed until some adhesion of the fragments has resulted, this may take from five to seven days. While heat and massage are given daily, the splint is not removed until the fifth day, when passive motion of the fingers and forearm is added. By the seventh day the splint is bandaged only as far as the wrist, so that free flexion and extension of the wrist and fingers are possible. The patients are urged to exercise the fingers and wrist regularly throughout the day so that relatively constant motion is obtained in addition to the periodic physiotherapeutic treatments. The splint is abandoned in the more complicated fractures between the tenth and seventeenth days. The objective is a complete return of function by the end of the third week. If closed reduction is unsatisfactory, open operation is indicated. These cases are comparatively rare, but in two in which displaced and rotated

comminuted fragments prevented reduction, operation was successful in effecting a good anatomical restoration.

Fractures of the Carpus.—The distribution of carpal fractures is noted in Table V.

TABLE V

Fractures of the scaphoid	10	Fractures of the semilunar	1
Fractures of the os magnum	1	Fractures of the navicular	1

There seems to be no standardized satisfactory method of treatment. The three fractures of the cuneiform, semilunar, and os magnum respectively, were partially immobilized in volar molded splints for three weeks, radiant heat and massage being started after the third day. The results in two instances were satisfactory, in the other, unknown.

Three of the scaphoid fractures were treated by rest in a simple volar molded splint with the wrist in extension for three to four weeks and by the application of physical therapy. The result was satisfactory in only one case. Four cases were operated on, the entire scaphoid being removed. Two were operated on immediately because of an associated semilunar dislocation, and the follow-up result in one was poor. Two cases were operated on because of persistent discomfort following conservative treatment, and while the patients were improved, they still complained of a weakened wrist. It would seem advisable at present to postpone operation until conservative measures of absolute immobilization have been tried. The carpus has been completely immobilized with the thumb in extension and abduction in three recent cases, the plaster extending from the elbow to the metacarpophalangeal articulation. After ten weeks, physiotherapy was instituted. Repeated X-ray examinations were made for evidence of bone healing. If discomfort should persist and non-union result, scaphoidectomy is indicated. In two cases followed, the result of this conservative treatment was excellent.

Fractures into the Phalangeal Joints.—Simple fractures of the phalanges involving joints were seen very rarely on the ward service. The treatment of these cases is immediate active and passive motion. Cases with marked displacement usually are associated with soft part injury and are frequently caused by crushing violence. The compromise of the highly specialized tendinous structures of the fingers may seriously impair function, and the results at best are not too promising. These cases are treated by traction obtained through needles passed through the terminal phalanges and attached to a banjo splint. Heat and massage are started immediately, and motion is encouraged as soon as feasible.

Fractures of the Os Innominatum.—The treatment of fractures into the acetabulum is similar to that of the average fracture of the pelvis. These cases, of which there were four, were given rest in a bed reinforced with a fracture board to insure greater immobilization. Active motion was permitted as soon as the patient could move without pain. At the end of six to eight weeks, the patient was allowed up with crutches, and these were discarded as

soon as possible. In two cases in which the acetabular cavity was actually driven inward by the head of the femur, no ill results were seen following this type of treatment. In fact, one patient was walking about with a normal gait and without complaint four months after discharge.

Traction and abduction in those cases in which the femoral head has been driven into the acetabular cavity were discontinued because they were found to be ineffective.

Fractures of the Upper Extremity of the Femur.—While an intracapsular fracture of the neck of the femur is a fracture into the joint cavity, it is really an extra-articular fracture with no actual compromise of the joint anatomy. The basic principles of the treatment of joint fractures, therefore, do not obtain. No differentiation was made between intra- and extra-capsular fractures. There were six cases in this group, one being treated by traction and the remainder in plaster spicas by the Whitman abduction method. The plaster cases were removed after three months; at this time the patients were fitted with walking Thomas caliper splints. These were worn until one year after the injury. The results were good in this small series.

Fractures of the Lower Extremity of the Femur.—Linear fractures of the femur entering the knee-joint either through the condyle or through the intercondylar notch without separation of the fragments can be safely started on immediate active motion. If joint effusions complicate these injuries, repeated aspirations may often be necessary. In cases in which the comminution and wide separation of fragments necessitate reduction, active motion is delayed until some healing of the fragments has taken place.

There were four cases in this series. Each of them will be briefly discussed as representative of a group problem.

One case, a joint fracture complicated by displacement of the lower end of the femur, was treated by a skeletal traction. Ice tongs were inserted into the lower end of the femur, and immediate active knee motion was instituted. Union was obtained in seventy-two days; at that time the tongs were removed. The patient was discharged with an excellent result.

The second case, one with a longitudinal fracture through the medial femoral condyle, was complicated by an enormous bloody effusion into the knee-joint. This was treated by repeated aspiration followed by active motion. The patient was discharged at the end of three weeks with crutches, and these were discarded at the end of two months. The final result was perfect in all ways. The third patient, one with a longitudinal fracture through the medial condyle into the joint, was treated immediately by active motion. The patient was walking about with crutches, bearing weight, at the end of seven weeks, and when seen four months later, had a perfect result. The fourth case, an oblique fracture through the lower third of the femur extending into the knee-joint with marked overriding, exemplifies a type of case in which it is advisable to delay motion. Traction with a Steinman pin through the head of the tibia was instituted, with a satisfactory anatomical reduction. Heat and massage were started within a week, but motion was delayed twenty-one days to allow some healing of the fragments to diminish the danger of displacement. This patient developed a mental condition necessitating transfer to another institution, but at the end of ten weeks had a satisfactory functional and anatomical result.

Fractures of the Patella.—There were twenty-nine in this series. The treatment is fairly well standardized and is dependent upon the degree of separation of the patella fragments. The treatment is conservative if the separation is negligible. There were nine cases of this type. The extremity was put at complete rest with a posterior splint to assure absolute immobility. In three cases in which effusion into the knee-joint was marked, aspiration was followed by the immediate application of a pressure bandage. In cases of marked soft part contusion, an ice bag was applied to relieve pain and reduce swelling. Active motion was started as soon as the pain had subsided sufficiently. The patients left the hospital after one to two weeks and were instructed to bear weight as soon as they could do so with comfort.

When the separation of the patella fragments is marked, operation is indicated. It should be performed immediately unless the overlying skin is abraded. Effusion into the knee-joint is no contra-indication. Twenty patients in this group were operated on, eleven on admission and nine at varying periods after the injury. The operation consisted of suture of the vasti expansions in sixteen cases, and of additional suture of the patella in four. The latter procedure is really unnecessary if the lateral expansions are properly sutured, although many clinics still practice direct approximation of the patella fragments with chromic gut, silver wire, or fascia. A posterior molded splint was always applied following operation.

If the post-operative course was uneventful, the patella was gently moved on the tenth day, and active motion was encouraged on the sixteenth. The patient was allowed up with crutches about the twenty-first day. The end-results of patella fractures were gratifying, for follow-up examinations usually disclosed a complete restoration of flexion and extension. There were no cases of refracture of the patella in this series.

Fractures of the Upper End of the Tibia.—Fractures of the upper end of the tibia involving the knee-joint were invariably caused by severe direct violence. Comminution, therefore, was the usual finding. The more severe injuries may be complicated by a rupture of the extrinsic or intrinsic ligaments of the knee-joint or by actual dislocation. In these instances the stability of the joint must be reëstablished by an adequate repair of the lateral ligaments before motion is instituted.

There were five cases in this series. In two there was fracture of the medial condyle; in two, fracture of the lateral condyle; in one, fracture of both condyles together with the intercondylar notch. Three were associated with fractures of the head of the fibula. For purposes of description these cases will be divided into simple and complicated varieties. In the three simple cases, the treatment consisted of rest in bed, immediate radiant heat, and light massage with motion starting as soon as the patient could bear the pain. Motion was started by the fourth day in four, after a week in one, and not until the thirteenth day in another because of associated injuries. While the knee-joints in these cases showed no marked effusion, they would have been aspirated if necessary, in order to promote a better range of motion.

Patients were allowed up with crutches after about two weeks but were instructed not to bear any weight until ten to twelve weeks had passed, especially if the fractures were comminuted and intercondylar. All these cases were seen in follow-up and presented excellent functional and anatomical results.

There were two cases of the complicated variety in which motion was delayed because of several factors. There was one case of dislocation of the lateral fragment and a slight subluxation of the knee. Motion was begun early but it was found that the subluxation and the separation of the outer fragment seemed to be greater. It was deemed advisable to delay further motion until sufficient union of the fragments had resulted. Although the case was complicated by a persistent phlebitis, which also delayed active motion, there was a reasonably good result.

The second case was an intercondylar fracture and fracture of the tibial spine with a rupture of the medial expansion of the knee-joint and a lateral dislocation. Two attempts at closed reduction were unsuccessful. This patient presented the problem of first repairing the ligamentous injury to assure anatomical restoration of the knee-joint. Naturally, motion must be delayed until sufficient repair has taken place to prevent redislocation. This patient was a chronic alcoholic and developed delirium tremens and bronchopneumonia which resulted in his death four days after admission.

Fractures of the Lower End of the Tibia and Fibula.—Fractures about the lower end of the tibia and fibula, entering the ankle-joint, were seen with almost the same frequency as those involving the knee. The three guiding principles in the treatment of fractures of the lower end of the tibia and fibula are a careful and accurate reduction with the maintenance of the anatomical integrity of the ankle-joint, early motion, and late weight-bearing. Any disturbance in the line of weight-bearing, poor ligamentous healing, or widening of the mortise of the ankle, either singly or collectively, tend to cause poor anatomical, functional and symptomatic results.

Reduction should be performed immediately. Experience has shown that better anatomical reduction can be obtained when anæsthesia is employed. Posterior and lateral molded plaster splints should be used to maintain reduction with the foot at a right angle and in marked inversion. The advantage of this type of splintage lies not only in its obvious safety but in its easy removal for the early application of physiotherapy. There were twenty-four fractures of the lower end of the tibia and fibula, the distribution and treatment of which are tabulated in Table VI.

TABLE VI

	Total	Reduction under Anæsthesia	Posterior and Lateral Splints
Fractures of internal malleolus	11	5	8
Fractures of external malleolus	2	0	2
Fractures of both malleoli	11	6	11

In simple fractures through one or both malleoli into the joint without displacement, heat, gentle massage, and active motion of the ankle were given immediately, but weight-bearing was delayed four to six weeks. In cases without severe ligamentous compromise in which anatomical reduction was necessary, massage and motion were usually started about one week after

injury with temporary removal of only the lateral splints. The posterior splint was usually temporarily removed after three weeks, and both were discarded about one week later. Weight-bearing was permitted after a lapse of six to eight weeks. In those cases in which the ligamentous injury had been severe enough to permit a dislocation of the foot, accurate anatomical reduction was the first requisite. The splints were left undisturbed for three weeks before physiotherapy was started. Weight-bearing in these cases was permitted about the tenth to twelfth week.

Twelve of these cases were seen subsequently, and the majority had good results although many complained of a persistent œdema about the ankle with some impairment of dorsi flexion.

Fractures of the Tarsus.—Fractures of the os calcis were the tarsal fractures most frequently encountered, and because of their importance they will be discussed in greater detail. Isolated fractures of the other tarsal bones are tabulated in Table VII.

TABLE VII

Fracture	Individual	Associated Fractures
Os calcis	19	Scaphoid, 3 Cuboid, 1
Cuboid	2	Tibia and fibula, 2 Os calcis, 1 Navicular, 1
Navicular	2	Cuboid, 1 Os calcis, 3 Tibia and fibula, 1
Astragalus	2	Tibia and fibula, 2

The treatment of the isolated fractures of the cuboid and navicular are quite similar. They consist of rest from weight-bearing for four weeks and the immediate institution of heat and massage. These cases were not simple, not comminuted, and the results were satisfactory. There was one case of astragalus fracture which was characterized by marked comminution, dislocation of the fragments, fracture of the malleoli, and rupture of the ligaments of the ankle-joint. It was impossible to replace the displaced fragments by closed manipulation or by traction by means of a pin through the os calcis. Astragalectomy was done with only a fair result.

There is probably no group of fractures which have a poorer functional prognosis than those of the os calcis. Fractures of this bone extending into the associated arthrodial joints are usually associated with a certain degree of comminution and displacement resulting in delayed union, non-union, and arthritis. These factors, as well as the exostosis incident to the splaying of the os calcis, are responsible for the persistent pain and disability on weight-bearing.

It has been very rare to accomplish anatomical restoration by non-operative measures such as molding the os calcis with a mallet, followed by immobilization in plaster. The best results seem to be obtained by a subastragaloid

arthrodesis. This procedure obliterates joint surfaces, practically eliminating the seat of disability.

In this series, there were nineteen cases of fracture of the os calcis involving the surrounding joints. Three of these cases were complicated by other fractures. Eleven of these cases were treated conservatively, operation being suggested to many, but refused. There is no doubt that occasional cases, especially those without comminution and deformity, may do well with rest and the application of a boot, but this is not the general rule. In eight cases a subastragaloid arthrodesis was done. It was customary to wait about three weeks before operation in order to allow the swelling, œdema, and ecchymosis incident to the primary trauma to subside. Following the operation, the foot is held at right angle and encased in a plaster boot for two months. A plate for support of the arch is made then, and the patients are encouraged to walk. The majority of these cases have been seen at the follow-up clinic, and the results have been gratifying not only from the anatomical but from the functional standpoint.

LATE RESULTS OF SEPARATION OF AN EPIPHYSIS

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In recent years considerable attention has been given to the late results of epiphyseal separation. Many of the articles in the literature comprise brief reports of one to three cases, as those of Meyer,[1] Field,[2] Sonnenschein,[3] and Newell[4] but with no report months or years after the injury, showing the terminal outcome. As it is rare for any individual to be able to observe the late results of any considerable number of these cases, a review was made of all of the cases with separation of the epiphysis admitted to the Children's Memorial Hospital from the years 1911 to 1931 inclusive. There were twenty-six patients showing this lesion. This analysis is based on the late results in eighteen of these patients, in whom there were nineteen epiphyseal separations. This group of eighteen includes all that could be traced for late examination.

Under the term "epiphyseal separation" various lesions have been described, but in this report only those cases in which the fracture passed through the epiphyseal cartilaginous plate as seen in Röntgenograms are regarded as epiphyseal separations. In addition, in some instances, the fracture extended also proximally or distally from this line. It does not include cases of wandering or slipped epiphyses, as described by Rabb,[5] Wilson,[6] and Badgley,[7] nor osteomyelitic processes, which according to Gold[8] cause epiphyseal separations in 12 per cent. of cases affected with osteomyelitis of the epiphysis. Also, it does not include those cases described by Werenskiold[9] who considers a separation of the epiphysis to be present when there is "a thin lamella detached from the epiphysis at the boundary between the bone and cartilage, and when displacement is not present, this may be the only, but sufficient proof of the existence of an epiphyseal separation." He found this lamella often forms without visibly displaced fragments, and says that this sign is present in 53 per cent. of epiphyseal separations. On this basis he classified 30 per cent. of 209 distal radial lesions as epiphyseal separations. According to him, undisputed epiphyseal separation is quite rare but Gold[10] reported an incidence of 25.9 per cent. of epiphyseal separations of the lower radius in fifty-eight radius fractures. He[8] also stated that 7.2 per cent. of children's fractures are separations of the epiphyses which is decidedly higher than the percentage at the Children's Memorial Hospital. From the years 1911 to 1931 inclusive, there were 1018 patients with fractures admitted into the hospital of which twenty-two (2.2 per cent.) were separations (four patients were treated in the dispensary and are not included in this calculation). In ninety-six cases of fracture of the upper end of the humerus, Roberts[11] reported three as epiphyseal separations. Poland[12] believed that

the epiphysis is often separated without displacement, but only cases showing visible displacement were included in this series.

Table I is a summary of the data obtained from an analysis of the cases in this series.

TABLE I

CASE I.—Female, aged one year. Causative agent.—Scurvy. Bone.—Left lower tibia. Amount of displacement of fragment in centimetres in X-ray before treatment.—.3. Treatment.—Antiscorbutic. Time from injury to final examination.—226 days. External shortening.—.5. Shortening in X-ray.—.6. Epiphyseal line present. Deformity. Functional result.—Normal.

CASE II.—Female, aged one year. Causative agent.—Scurvy. Bone.—Left and right lower femurs. Amount of displacement of fragment in centimetres in X-ray before treatment.—Left, .7; right, .5. Treatment.—Antiscorbutic. Time for injury to final examination.—224 days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE III.—Female, aged two years. Causative agent.—Fall. Bone.—Right upper femur. Amount of displacement of fragment in centimetres in X-ray before treatment.—1.6. Treatment.—Closed reduction. Time from injury to final examination.—Seven years, 192 days. Epiphyseal line present. No deformity. Functional result.—Pain when jumping.

CASE IV.—Male, aged three years. Causative agent.—Fall. Bone.—Left capitellum humeri. Amount of displacement of fragment in centimetres in X-ray before treatment.—3. Treatment.—Open operation. Time from injury to final examination.—One year, 144 days. External shortening.—1.3. Shortening in X-ray.—2. Epiphysis absent. Deformity. Functional result.—Poor.

CASE V.—Female, aged seven years. Causative agent.—Hit by rubber tubing. Bone. Left second metacarpal. Amount of displacement in centimetres in X-ray before treatment.—.3. Treatment.—Open operation. Time from injury to final examination.—Four years, 127 days. External shortening.—.6. Shortening in X-ray.—.6. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE VI.—Male, aged eight years. Causative agent.—Fall. Bone.—Left upper radius at right angle to the shaft. Treatment.—Closed reduction. Time from injury to final examination.—Three years, 198 days. Shortening in X-ray.—.2. No epiphyseal line present. No deformity. Functional result.—Normal.

CASE VII.—Male, aged eight years. Causative agent.—Fall. Bone.—Right upper radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—.5. Treatment.—Closed reduction. Time from injury to final examination.—303 days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE VIII.—Male, aged nine years. Causative agent.—Fall. Bone.—Right lower radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—1. Treatment.—Closed reduction. Time from injury to final examination.—Two years, thirty-two days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE IX.—Male, aged nine years. Causative agent.—Struck finger. Bone.—Right fifth metacarpal. Amount of displacement of fragment in centimetres in X-ray before treatment.—.2. Treatment.—Closed reduction. Time from injury to final examination.—One year, 211 days. Shortening in X-ray.—.3. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE X.—Male, aged nine years. Causative agent.—Fall. Bone.—Right lower radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—.5. Treatment.—Closed reduction. Time from injury to final examination.—230 days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE XI.—Male, aged ten years. Causative agent.—Fall. Bone.—Left lower radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—2.2.

Treatment.—Closed reduction. Time from injury to final examination.—Seventy-four days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE XII.—Male, aged ten years. Causative agent.—Fall. Bone.—Right lower humerus (medial epicondyle). Amount of displacement of fragment in centimetres in X-ray before treatment.—1.3. Treatment.—Closed reduction. Time from injury to final examination.—187 days. Shortening in X-ray.—.8 longer. Epiphyseal line present. Deformity. Functional result.—Normal.

CASE XIII.—Female, aged eleven years. Causative agent.—Fall. Bone.—Left upper radius at right angle to the shaft. Treatment.—Open operation. Time from injury to final examination.—Three years, thirty-six days. External shortening.—1. Shortening in X-ray.—1. No epiphyseal line present. No deformity. Functional result.—Normal.

CASE XIV.—Male, aged eleven years. Causative agent.—Struck box. Bone.—Right fourth finger, third phalanx. Amount of displacement of fragment in centimetres in X-ray before treatment.—.5. Treatment.—Open operation. Time from injury to final examination.—Three years, 211 days. External shortening.—.2. Shortening in X-ray.—.3. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE XV.—Male, aged eleven years. Causative agent.—Fall. Bone.—Left lower radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—1.2. Treatment.—Open operation. Time from injury to final examination.—Eighty-nine days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE XVI.—Male, aged eleven years. Causative agent.—Fall. Bone.—Right lower radius. Amount of displacement of fragment in centimetres in X-ray before treatment.—.4. Treatment.—Closed reduction. Time from injury to final examination.—Eighty-four days. Epiphyseal line present. No deformity. Functional result.—Normal.

CASE XVII.—Female, aged twelve years. Causative agent.—Hit by falling man. Bone.—Left lower tibia. Amount of displacement of fragment in centimetres in X-ray before treatment.—.5. Treatment.—Closed reduction. Time from injury to final examination.—272 days. External shortening.—1. Shortening in X-ray.—.6. No epiphyseal line present. No deformity. Functional result.—Normal.

CASE XVIII.—Male, aged thirteen years. Causative agent.—Fall. Bone.—Left lower tibia. Amount of displacement of fragment in centimetres in X-ray before treatment.—.3. Treatment.—Closed reduction. Time from injury to final examination.—182 days. Epiphyseal line present. No deformity present. Functional result.—Normal.

In this series there were six girls and twelve boys ranging in age from one to thirteen years, with an average age of eight years and forty days. Except in two cases which were due to scurvy (Figs. 1, 2, and 3), as described by Hess[13] and many others, all of the separations were caused by injury. None were due to muscle strain (Kahnt[14]), birth injury (Harrenstein[15]), or syphilis, and none occurred spontaneously.

Separation of the lower radial epiphysis was the most frequent in Gold's[10] cases, as it is in this series, in which it occurred six times (31.6 per cent.) in the nineteen separations. Upper radial epiphyseal separation stands second with three cases; the lower tibia, lower femur, lower humerus, and metacarpus are third with two cases each; and there was one of the upper femur and one of a phalanx of a finger.

The amount of displacement, as measured in röntgenograms, varied from 0.3 centimetre to 3 centimetres with an average displacement of 0.9 centimetre.

Five patients were treated by open operation, eleven were treated by closed reduction, and the two scorbutic patients were given only antiscorbutic medication and diet.

The shortest period of time that elapsed from the time of injury till the final examination was seventy-four days, the longest was seven years and 192 days, and the average was 646 days. Perhaps, if these patients were followed longer, more sequelæ would be found.

The examinations were made especially for late sequelæ including (1) shortening of the bones; (2) premature ossification of the epiphysis to the diaphysis with obliteration of the epiphyseal line; (3) deformity such as cubitus varus in capitellum humeri separation, cubitus valgus following

FIG. 1.—(Case II.) Scurvy. Appearance of the lower femoral epiphyses before treatment. Note the slight increased calcium deposit just above the epiphyseal lines.

epicondylus medialis humeri separation, and coxa vara; (4) arthritic changes; (5) Perthes' disease and cyst formation, and (6) functional disturbances.

(1) *Shortening.*—This lesion of bones has been especially stressed by Harrenstein,[15] Gold,[8] Linser,[16] McFarland,[17] and Watson.[18] Of the nineteen cases, six (31.6 per cent.) had shortening by external measurements and eight (42.1 per cent.) by röntgenogram measurements, which no doubt are more accurate. In a comparison of the results that others have found, Klinefelter[19] reported twelve cases of epiphyseal separations, three (25 per cent.) of which had arrest of growth. In contrast, Zadek[20] reported five cases of separation of the epiphysis of the lower end of the radius, in patients aged

nine to thirteen years, of which two were operated upon and three were treated by closed reduction, and none of them showed subsequent shortening.

Considering the short period of time in which shortening can occur, McFarland[17] stated that definite shortening may occur within seven months subsequent to the injury. This is quite in agreement with what was found in Case I (scurvy with separation of the lower epiphysis of the tibia), in which a shortening of .6 centimetre was observed in röntgenograms 226 days after the onset. This is the briefest period of time in which a decrease in length was observed.

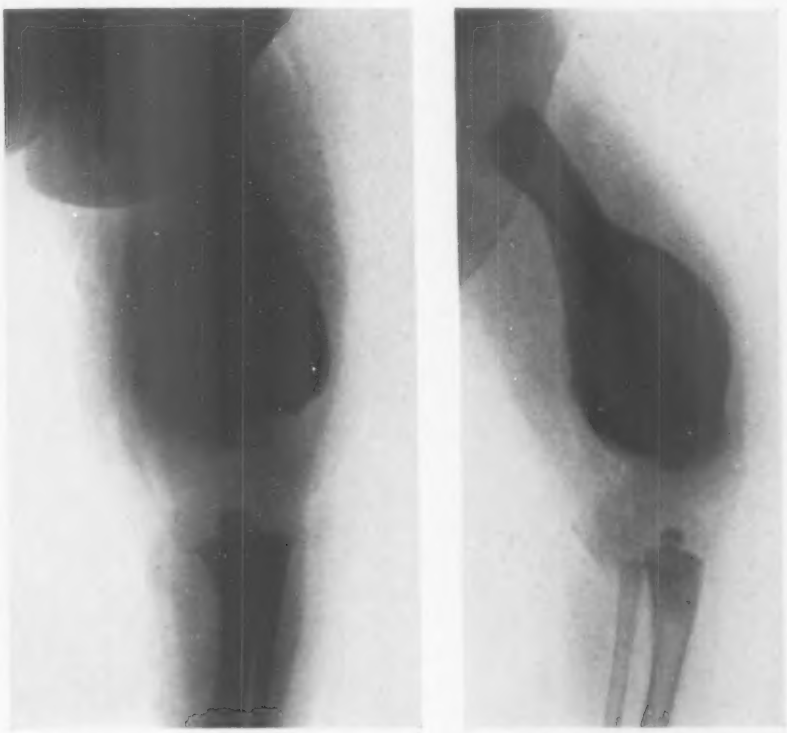

FIG. 2.—(Case II.) Scurvy. Same patient as in Fig. 1, but after thirty days of treatment. Note both lower femoral epiphyses separated and large, heavy bony deposit extending upward along the shafts.

There is some disagreement in the literature as to whether shortening may be expected. Speed[21] in 1916 had seen no cases of cessation of growth after a separation of the epihysis of a long bone but later did see such cases. Patterson[22] thinks that the danger of interference with growth has been exaggerated. Indeed, epiphyseolysis of the lower femur has been used as a corrective measure in genu valgum but Jones and Lovett[23] believe that in unskilful hands it is definitely dangerous. However, the above data show that shortening is quite common. Gold,[10] who concurs in this opinion, thinks that separation of the lower epiphysis of the femur is very often followed by premature ossification and cessation of growth. Willis[24] stated that a lesion of the upper epiphysis of the femur is always followed by a permanent

fusion of the epiphysis and consequent effect upon growth. This view, however, is not substantiated by Case III of this series which shows no evidence of the old injury in röntgenograms taken seven years and 192 days after the accident and has no shortening.

The causes of the shortening have been attributed to various factors. In the upper extremity, Linser[16] mentions a case of separation of the upper epiphysis of the humerus with 14 centimetres of shortening because apposition was not good. However, poor apposition is not the only factor concerned because in Case XIII (previously reported by Montgomery[25]) the head of the radius was perfectly replaced at operation. This was confirmed post-operatively by röntgenogram, and yet there was 1 centimetre of shortening at the last examination (three years and thirty-six days after injury). Henderson[26] thinks that shortening is due to inactivity of the growing centres. Haas[27] is inclined to believe that a vascular disturbance is the cause of growth disturbance. However, the excellent work which he has done on epiphyseal transplantation in dogs does not absolutely prove that vascular disturbance is the only factor involved in shortening, because nerve injury has resulted in epiphyseal arrest of growth, and this factor was not excluded in his work. McFarland[17] thinks that the failure of growth is due to death of cartilage cells either from being crushed or from hæmorrhage into them. He states that a lower radial epiphysis separation is less likely to be followed by shortening than a lower tibial separation. In discussing the lower radial epiphysis he says that only when it is crushed does arrest of growth occur, but does not state how he arrived at this conclusion. He proved, however, that if one-half of the epiphysis of the lower tibia is injured, the injured portion may cease to grow, while the uninjured side continues, thus making a deformity.

In addition to the above etiological factors, Küttner[28] found that root and plexus paralysis in childhood caused decrease in the growth of bones. Löhr-Magdeburg[29] found shortening due to hæmophilia and ischæmic contractures. Experimentally, he observed that in freezing the epiphyses in rats shortening ensued and that in freezing of the joints and epiphyses, more damage was done to the epiphyses than to the joints.

The patients in this series were examined to determine whether the amount of displacement of the fragments, both before and after reduction, had any influence on shortening. Two patients (Cases VI and XIII), with upper radial epiphyseal separations, had the epiphyseal fragment turned at a right angle to the shaft. Although a perfect reduction was obtained, both had shortening at the last examination with the epiphysis of each showing osseous union to the shaft, but neither had deformity or impaired function. Case XI, who had 2.2 centimetres of displacement of the fragment before reduction, which was the second greatest amount of any in the series, obtained a perfect result in every respect, while Case IX, who had only .2 centimetre of displacement before reduction showed a shortening of .3 centimetre in a röntgeongram one year and 211 days after injury. After reduction, the fracture of Case XI still showed .5 centimetre displacement in röntgeno-

gram, yet no shortening developed. On the other hand, after reduction, Case XVII still had .5 centimetre displacement, and subsequently had shortening and premature ossification of the epiphysis to the shaft. These observations show that displacement does not necessarily produce shortening and in cases where shortening has occurred, the amount of shortening does not depend upon the amount of displacement. Hence, no conclusion can be drawn as to whether shortening would or would not follow a separation with a stated amount of displacement of the fragments either before or after reduction.

An increase in bone length, such as has been reported in some patients

FIG. 3.—(Case II.) Scurvy. Appearance of the lower femoral epiphyses in alignment, one hundred sixty-nine days after beginning treatment. Note disappearance of the large bony deposits.

with osteomyelitis (Speed[30]) occurred in one patient (Case XII). The cause of this lengthening is not clear. The theory is offered that the injury may have stimulated the growth of epiphyseal cartilage cells to cause the increase in length of the bone.

(2) *Premature ossification of the epiphysis to the diaphysis.*—This abnormal ossification, as described by Löhr-Magdeburg,[29] Montgomery,[25] Lapidus,[31] Gold,[10] and Kurlander,[32] occurred in three patients (16.7 per cent.) in this series. All of these had shortening, but other than this, none of them had any deformity. However, in four patients (Cases I, V, IX, and XIV) in which there was shortening, the epiphyseal line was still present. It would seem that a certain amount of damage may be done to the epiphyseal cartilage

plate (*i.e.*, enough to cause shortening) and still be insufficient to cause ossification of the epiphysis to the shaft.

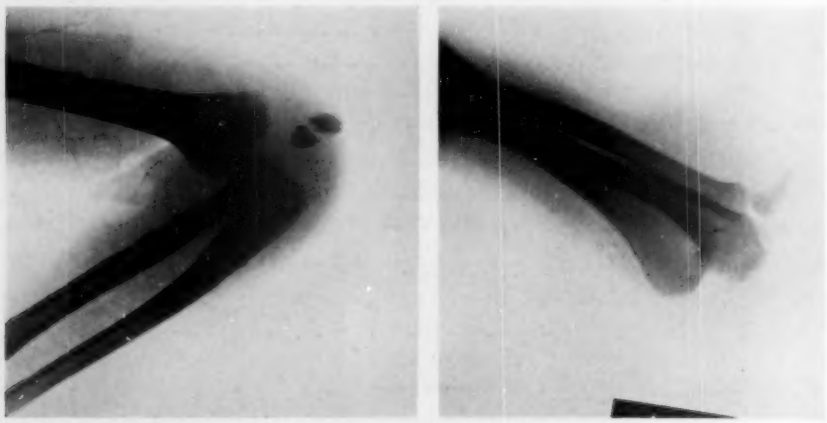

FIG. 4.—(Case IV.) Capitellum humeri separation with fragment displaced laterally. Upper end of ulna is also fractured.

Several theories have been offered to explain this premature ossification. Ferguson and Horworth,[33] and Haas[27] have suggested that the premature union of the growth centre is evidence of a circulatory disturbance.

FIG. 5.—(Case IV.) Capitellum humeri separation thirty-seven days after injury. Note marked lateral displacement of the capitellum.

Lapidus[31] stated that the premature disappearance of the epiphyseal cartilage with complete union of the lesser trochanter to the shaft of the femur

as shown in röntgenograms takes place in about four months. The shortest period of time in which there was a premature disappearance of the epiphyseal cartilage in this group of cases, as seen in röntgenograms, was 154 days. This occurred in Case XVII, with a lower tibial epiphysis separation.

(3) *Deformity.*—Only three patients had deformity other than shortening.

In Case IV the capitellum humeri were separated (Figs. 4 and 5). This patient was treated by a closed reduction followed by a plaster bandage with the elbow in acute flexion. After removal of the bandage, massage and wet soaks were employed. After reduction, the displacement was 2.5 centimetres, but thirty-eight days later it was 3 centimetres, indicating that the fragment had slipped while in the case. As extension and flexion of the elbow were quite limited one year and one hundred and forty-four days after the injury, an open operation was done in an attempt to nail the capitellum in place. However, it was found that when this was accomplished, flexion and extension were not improved, so the capitellum was excised and the ulnar nerve transplanted anteriorly to prevent its being pinched between the olecranon and the inner condyle. The joint is now somewhat flail, cubitus varus is present and when the elbow is flexed at an angle of 90°, pronation of the forearm can be carried out beyond the normal limit. Probably it would have been better to have made further attempts to align the fragments at the onset, perhaps by performing an open operation and suturing the periosteum with catgut. With this patient in mind, all possible means will be utilized in the future to secure proper alignment in capitellum separations. The seriousness of this lesion has been previously emphasized by Gold[8] who called attention to the incidence of cubitus varus resulting from it.

The second patient (Case I) with deformity, suffered from scurvy and genu recurvatum and genu valgum resulted, as described above. The third patient (Case XII), who had epicondylus medialis humeri separation, had only a slight prominence of this region, which was not considered serious. However, Gold[8] had called attention to the fact that cubitus valgus may follow this lesion.

Deformity is more prone to follow certain epiphyseal lesions. McFarland[17] stated that progressive deformity is only present in a very small proportion of separations of the lower epiphysis of the radius, but that the reverse is true of the tibia. Harrenstein[15] and Hess[13] mentioned that coxa vara may follow separation of the upper epiphysis of the femur. Friedrich[34] reported a case of coxa vara presumably from an epiphyseal disturbance which occurred fifty years previously, but it is difficult to understand how he arrived at the conclusion that it was an epiphyseal lesion which caused the coxa vara. Recently, Esau[35] stated that lower ulnar epiphysis injury may cause a very disabling deformity and suggested that this lesion may be the cause of Madelung's deformity.

Other sequelæ have been reported as following epiphyseal separations. Kurlander[32] reported three cases of separation of the lower femoral epiphysis, one of which was followed by gangrene necessitating amputation at the mid-thigh.

Ankylosis was not observed in any case in this series. Cutler[36] reported five cases of separation of the lower femoral epiphysis, one of which was followed by a permanently stiff knee and another by external popliteal nerve paralysis. Eikenbary and LeCocq[37] reported ten cases of upper femoral

epiphysis separation with the following results: good, four; poor, four, and excellent, two. Two patients were operated on and ankylosis occurred in both.

Following epiphyseal separations, non-union seems to be more rare than after simple fracture of the shaft and no cases of non-union were observed in this series. Watson[18] stated definitely that there have been no cases of non-union following lower radial epiphysis separation. Poland,[12] quoting Hamilton, reported a patient with non-union five months after an injury which produced a separation of the epiphysis of the upper end of the humerus. However, this patient had had no treatment of any kind.

(4) *Arthritis.*—There was only one case (Case IV) with arthritic changes. This occurred in the patient (Figs. 4 and 5) with capitellum separation who was treated by removal of the fragment, as described above. It is questionable whether some of the arthritis in this patient may not be due to operative interference or whether it is all due to absence of the capitellum. Also, this arthritis may become worse later on, as Madlener and Wienert[38] examined patients for arthritis deformans following olecranon fracture and found that the longer the time since the injury, the more decided were the joint changes.

It is difficult to decide in many cases of arthritis which have been preceded by an epiphyseal separation, just how much the separation contributed to the arthritis. Friedrich[34] believes that the greater percentage of arthritis deformans of the hip is the result of early hip disease of some type. However, the case of arthritis of the upper end of the humerus due to an epiphyseal injury in a man seventy-four years old, reported by Nussbaum,[39] is open to question, because it would seem difficult to decide what the etiological factor was in a case of so long duration.

(5) *Perthes' disease, cyst formation, etc.*—There were no patients in this series in which Perthes' disease, as described by Driver,[40] or cyst formation, as described by Muller,[41] occurred. Nussbaum[42] reported cases of chondroma and osteitis fibrosa probably due to separation of the upper epiphysis of the femur, but Walter[43] casts some doubt on this assumption.

(6) *Function.*—Only two patients had poor function. One of these (Case III), with a separation of the upper epiphysis of the femur, had pain on jumping. An examination of this patient showed no apparent cause for the poor function. Röntgenograms taken after reduction showed a perfect apposition of the fragments and röntgenograms taken seven and one-half years later showed nothing abnormal. Apparently, this case does not substantiate the hypothesis of Field,[2] who, in discussing this particular lesion, stated: "A return to perfect function, one would surmise, would follow a complete and accurate reduction with efficient after-treatment."

The other patient (Case IV), with a capitellum humeri separation, had a flail elbow, as described above. Possibly, the poor result in this patient might have occurred without the removal of the capitellum. However, it is more likely that removal of the capitellum led to the poor result. The operation should not be undertaken in a child before epiphyseal growth has ceased,

without due consideration of a probable subsequent deformity and loss of function.

In this series one patient showed then slight impaired function from no apparent cause and another showed marked loss of function probably from injudicious treatment. It would seem from this that function is not commonly interfered with, following epiphyseal separation.

Scurvy.—A further word should be added in regard to the treatment of the two patients with scurvy. (Figs. 1, 2, and 3.) Hess[13] has suggested that splints be applied to patients suffering from scurvy with epiphyseal separations, but no mechanical appliance was used in the treatment of these two patients. During the active stage of the disease, they were kept lying flat in bed, given anti-scorbutic diet, viosterol, sun baths, and cod-liver oil. Fractures in scurvy apparently heal quite readily, since Roegholt[44] found that in guinea-pigs affected with scorbutus, fractures began to show healing in röntgenograms five days after vitamin C administration.

The result was poor in one patient but excellent in the other. Case I, at the last examination (226 days after the onset), had genu valgum with 6 millimetres of shortening by external measurements and 5 millimetres in the röntgenogram. Better results might have been obtained if a plaster fixation bandage or other appliance had been used. The other patient with scurvy (Case II) also suffered with cretinism. In addition to the above medication she received desiccated thyroid. At the last examination (224 days after the first examination), she had recovered from the scurvy and röntgenograms showed the previously separated epiphyses to be normal.

Factors to be considered in the prognosis.—Different factors must be considered when the various epiphyses are separated. These include the particular epiphysis involved, the age of the patient, and the amount of displacement of the fragments.

The particular epiphysis involved must be considered in the prognosis because separations of some epiphyses seem to be more important than others. Watson[18] and Speed[45] stated that the epiphysis toward which the nutrient artery points usually unites with the shaft first. One exception to this rule is the fibula, as pointed out by Speed[45] and Harbin and Zollinger.[46] Watson[18] stated that the greatest longitudinal growth is produced by the epiphysis which unites last.

One would suspect, other conditions being the same, that the greatest amount of shortening would follow separation of the epiphysis which unites last, but this was not confirmed by an analysis of Table I. Comparisons can be made with only two bones, the femur and radius. There were two patients with lower femoral epiphyseal separations and one with upper, but none of them had shortening. There were five patients with lower radial separations none of whom had shortening as one would expect, but there were three of upper radial separations, two of which had 1 and 2 centimetres of shortening, respectively. It is clearly seen, however, that this number is too small to form any definite conclusions.

Griswold[47] thought that separation of the lower epiphysis of the femur should be treated by early motion and he treated such a case with complete motion of the femur within seventeen days after reduction and an examination 309 days after the injury showed an excellent result.

The age of the patient is naturally important because the younger the individual, the greater is the risk of shortening and deformity. For instance, one would consider that more shortening would occur in a separation of the lower epiphysis of the tibia which occurred at the age of one and one-half years (one year after the epiphysis forms) than one which occurred at the age of seventeen years (one year before it closes).

The amount of displacement of the fragments, both before and after reduction, according to some authors, must be given due consideration in estimating the prognosis. However, as stated above, no definite conclusions in this respect could be drawn from this series. One is at a loss to say exactly how many millimetres the epiphysis must be displaced as measured in the röntgenograms before operative interference should be undertaken. The question of whether a separation in any individual instance is to be treated by closed reduction or open operation is often difficult to decide. It has been suggested by Linser,[16] Conwell,[48] and Roberts[11] that better results may be expected when apposition is good. This is in agreement with Speed[21] who stated that a perfect reduction of an epiphyseal separation gives a correspondingly good prognosis, but this is not substantiated by the result in Case XIII, who had perfect alignment, as seen in röntgenograms taken after reduction, and yet had 1 centimetre of shortening. However, this patient was operated upon and the operative trauma may have tended to negative the result.

Judging from the results in this series, open operation is to be avoided if it is possible to obtain a reduction of the fragments otherwise, as none of the five patients operated on had perfect results. Cutler[36] and Eikenbary and LeCocq[37] had similar experiences. On the other hand, Zadek[20] who operated on two patients with separations of the lower epiphyses of the radius had very satisfactory results.

Foreign material placed in the region of the epiphysis should be avoided if possible because of growth interference. If used, it should be of an absorbable nature by preference, or if non-absorbable material is used, it should be removed after the callus becomes hard enough to maintain the position of the fragments. A very good method for holding the fragments in position is to suture them with twenty- or thirty-day No. 3 or 4 catgut, used double if necessary. This is better than kangaroo tendon which is more likely to lead to a suture sinus.

The degree of periosteal separation may be a factor in the prognosis, since Poland[12] stated that the periosteum is the most important element in the production of the callus. If so, the conclusion may be drawn that the more the periosteum is separated, the greater will be the disturbance of the epiphysis. However, it would be difficult to estimate the degree of periosteal separation in any given case. Lapidus[31] believes that the periosteum is only slightly

stretched in separation of the epiphysis of the lesser trochanter of the femur and that the repair in these cases is so good that operation is not indicated. The results obtained by Vadsten[49] with the closed method in separations of the lesser trochanter tend to substantiate this belief.

Summary.—Eighteen patients with nineteen epiphyseal separations were examined from seventy-four days to seven years and 192 days following the epiphysis separation. Sixteen of these separations were due to trauma and three to scurvy. Eleven patients were treated conservatively by closed reduction. Of these, one had shortening and one had lengthening as measured in röntgenogram, two had osseous union of the epiphysis to the shaft, one had deformity and one had poor function, but none had arthritis. Two patients with three epiphyseal separations due to scurvy were treated by simple rest in bed without splints but were given anti-scorbutic food and medication. One had shortening and deformity, but in neither was there osseous union of the epiphysis to the shaft, impaired function, or arthritis. Five patients were treated by open operation. All of these had subsequent shortening as measured in röntgenograms and four showed shortening by external measurements; one had osseous union of the epiphysis to the shaft; and one after removal of the epiphysis had a resulting deformity, poor function, and arthritis.

Open operation is to be avoided if the fragments can be approximated otherwise. Judging from the results obtained in this series, open operation should be done only when absolutely necessary, as it seems to cause a poor result.

The outlook in regard to deformity and function seems to differ in the various epiphyses. The poorest results seem to follow epiphyseal separations of the capitellum humeri, epicondylus medialis humeri, upper and lower femur, lower tibia, upper humerus, lower radius, and lower ulna. There were only three patients with deformity (capitellum, epicondylus medialis humeri, and lower femoral epiphysis separations) and two with poor function (capitellum and upper femoral epiphysis separations). In one patient with a separation of the lower tibial epiphysis deformity will probably occur in a few years, because there is now bony ossification to the shaft at the median aspect and the patient is only twelve years old. This epiphysis normally closes at the age of eighteen years.

All the cosmetic changes were due to shortening and deformity. In only two patients (metacarpal and phalanx of finger separations) was there enough shortening to produce any bad cosmetic effect, and in only three patients (lower femoral, capitellum, and median epicondyle separations) was there a deformity, other than shortening, causing a poor cosmetic result.

Although it might be expected that the greatest amount of shortening would occur in injuries to the epiphysis which unites last in any particular bone, no conclusion could be drawn in regard to this matter from the observations made on this group of patients.

The amount of separation of the fragments as measured in the röntgeno-

gram, either before or after an attempt at alignment, is apparently of no prognostic value as to possible sequelæ. The essential factor is undoubtedly concerned with the integrity of the epiphysis. At the present time there do not seem to be any evident criteria by which this can be determined.

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FRACTURES OF THE HEAD AND NECK OF THE RADIUS

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The frequency of fracture of the proximal end of the radius, as compared with other fractures about the elbow, is approximately 3 per cent. It is, therefore, not a rare fracture; neither is it a common one. There have been 420 fractures about the elbow admitted to the Children's Fracture Clinic at Bellevue Hospital in the past ten years. Of this number only fourteen were of the proximal end of the radius.

This fracture is caused by both direct and indirect violence. In children it is about equally divided, while in adults direct violence is more common.

Diagnosis, as a rule, is quite simple. There is a history of either direct or indirect violence. The physical findings are: A swelling about the elbow, point tenderness over the head of the radius, normal relationship of the epicondyles and olecranon; crepitus is not usually present. The arm is held in partial flexion and semipronation. Motion about the elbow in any direction is painful. This is especially true of rotation. (Usually flexion and extension are not painful except in extreme position.) If the forearm is passively rotated, the head of the radius does not rotate with it. Pain and swelling over the dorsum of the hand frequently occur.

By careful examination one can usually make an accurate diagnosis; but the final and definite diagnosis must depend upon X-ray examination. X-ray pictures taken in two planes will determine the presence of and the particular type of fracture.

For purposes of treatment these fractures may be divided into three groups. *The First Group.*—Includes simple fractures without displacement of the fragments. It is generally agreed that this type of fracture should be treated conservatively. The arm is placed in moderate flexion with the hand in complete supination, in a posterior molded plaster splint, and held in this position for two weeks. This splint should be removed at intervals and active motion instituted, then replaced. At the end of two weeks the splint is permanently removed. The elbow is then baked and massaged. If so treated the results are universally good.

The Second Group.—Includes simple fractures with displacement of fragments, where the orbicular ligament is not badly damaged and where the fracture line does not involve the articular surface. These fractures should be operated at once, the fragment replaced in its normal position and held there by suture of the ligaments and muscles, or by the use of a band of fascia lata. The forearm must then be so placed as to best maintain this position, which can usually be accomplished by moderate flexion and semipronation. With the arm firmly held in this position by an assistant, the

wound is closed and a posterior molded plaster splint applied. The treatment then followed is the same as that given the cases in Group One.

The Third Group.—Is composed largely of the comminuted and badly displaced fractures which cannot be satisfactorily replaced. Resection of the head in these cases is imperative. A chip fracture of the head, which does not rotate in the lesser sigmoid cavity of the ulna, *i.e.*, a small lateral fragment, may be dealt with by simple removal and repairing of the orbicular ligament.

The growth of bone in children, which is usually a great adjunct and which in most fractures may be relied upon to correct deformity, cannot be depended upon to the same degree in fractures of the upper end of the radius. It has been a source of great disappointment to us to find a marked tendency to proliferative periostitis in both operated and non-operated cases, with a resultant synostosis between the radius and ulna. The immediate post-operative results usually are very good; flexion and extension readily return to normal. Rotation, which is a most important function of the elbow-joint, is also satisfactorily restored. In some of these cases the follow-up shows a gradual thickening of the proximal end of the radius, beginning as a productive periostitis, causing a gradual loss of rotation which finally becomes complete and due, of course, to a synostosis of the radius and ulna. This condition is not easily corrected, as was shown by one of our earlier cases in which the callus, together with the involved upper third of the radius, was carefully resected. Full rotation was restored only to be again completely lost by reformation of the resected portion and more callus, causing a recurrence of the synostosis.

In judging end-results in fractures of the head and neck of the radius, there are four major considerations, *viz:* (1) Pain. (2) Stability of the elbow-joint. (3) Function. (4) Anatomical deformity. All, of course, are interrelated, especially pain and stability. Pain is, however, the greatest disability from the patient's point of view. It is usually in direct proportion to instability, so in choosing the type of treatment for a given fracture, these two considerations must receive the greatest attention.

Function.—Since the head of the radius enters into two distinct joints, it naturally contributes to both functions, *viz.:* flexion and extension and supination and pronation of the forearm. Fortunately, in fracture of the head and neck of the radius, flexion and extension are seldom limited. However, it occasionally occurs from excess callus or the formation of a loose body which locks the joint and prevents this function. Rotation, on the contrary, a most useful movement, is where we find most of our loss of function. This is usually due to synostosis of the radius and ulna, in the region of the fracture. It is most difficult to prevent and, indeed, in some cases that have a tendency to prolific callus formation, it is impossible. In order to avoid this disturbance, where open operation is done, extreme care should be exercised to remove all spicules of bone and shreds of periosteum.

The end of the radius should be smoothed off and the orbicular ligament carefully repaired.

In spite of these precautions, synostosis, with complete loss of rotation, occurred in 50 per cent. of the children operated upon for removal of the head of the radius. In none of these cases could a satisfactory replacement be accomplished. It is, however, surprising how this loss of function is compensated by the rotators of the arm and scapular muscles.

Anatomical deformity is, fortunately, not very great in this fracture. An increased carrying angle of the forearm is always found and is practically the only deformity.

In operated cases the prognosis cannot be made from inspection of the histories and operative findings, since very similar cases give opposite results. For instance, "G. Y.," a girl of six, had a minimum of trauma. She fell while roller-skating. She was operated promptly by Bohrer, who used the same technic and same post-operative treatment as in the case of "J. S.," a girl of nine, who also fell while roller-skating. The X-ray pictures were quite comparable in the two cases, yet in "G. Y." the radius and ulna became synostosed and she lost her rotation, while "J. S." resulted in normal restoration of function.

This is also true in cases operated by Beekman. "W. D.," a boy aged ten years, operated seven days after the accident, resulted in normal restoration of function; while "R. M.," a boy of ten, operated ten days after the accident, resulted in synostosis of the radius and ulna.

From observation of these reported cases over a prolonged period of time and a review of the literature, I have come to the following conclusions:

(1) Fracture of the head and neck of the radius, in children, should be treated conservatively unless there is marked displacement of the fragment.

(2) In cases of marked displacement of the fragment, early operation with replacement of the fragment is preferable to resection.

(3) If resection is done, about 50 per cent. will develop synostosis of the radius and ulna in the resected area. This synostosis occurs several months after operation.

(4) In resected cases a stable, non-painful joint may be expected.

(5) Flexion and extension are seldom limited.

(6) In resected cases an increased carrying angle always develops, apparently from a lack of growth at the proximal end of the radius.

(7) In adults: Simple fracture with displacement, even if the fracture line involves the articular surface, should be treated conservatively.

(8) In operative cases resection of the entire head of the radius is the operation of choice. A stable, non-painful joint, without loss of function, may usually be expected.

SUMMARY AND ANALYSIS OF CASES

(1) Of twenty cases which form the basis of this report, twelve were treated conservatively. Those with slight displacement have excellent results.

Those with marked displacement have loss of rotation and some loss of flexion and extension.

(2) Of the children's cases, five were operated for resection of the head of the radius. Two recovered full function permanently; three had complete function when discharged from the hospital, but over a period of several months, rotation was lost from productive periostitis followed by synostosis of the radius and ulna.

(3) Of the children's cases nine were treated conservatively. Three of these had severe injuries with displacement or comminution of the head of the radius; two became synostosed with loss of rotation; one recovered complete function. The remaining six, with slight trauma, recovered complete function.

(4) One adult case, operated for resection of the head of the radius, resulted in complete restoration of function. Another adult case, where replacement of the fragment was done, resulted in loss of rotation and 20 per cent. loss of flexion and extension.

(5) Of the adult cases, four were treated conservatively. Three recovered complete function; while the fourth, whose fracture involved the joint surface, has limited motion in all directions.

LITERATURE.—There is considerable difference of opinion among authors on the advisability of treating this fracture operatively or conservatively.

Culp[2] reports four cases, all adults, in which the fractured head of the radius was removed. There was complete restoration of function, with minimum loss of time.

The conclusions of Key's[3] excellent paper are: "Certain fractures of the upper end of the radius should be treated conservatively, others should be treated by immediate operation with either removal or replacement of the head, and others should be treated expectantly and the head removed later if necessary. In children, the displaced head of the radius can be replaced by open operation and a practically normal elbow and forearm may be expected.

"After early removal of the head of the radius, a satisfactory but not a normal elbow and forearm may be expected.

"Traumatic arthritis is the result of function in a disorganized joint, and late removal of the head of the radius after the arthritis has developed will not as a rule cure the arthritis."

E. Lassen,[4] of Copenhagen, believes in conservatism. He reported seventy-one cases. Sixty-three were treated conservatively. Subsequent examinations were done in fifty-seven cases, including the eight operative cases. Thirty-one of the fifty-seven were good functional results; moderately good in fourteen, and poor in four. (The operative cases did not give good results.) Open operation was used only in grave fractures and, with but a single exception, was performed at a late date.

Pfab[5] reports fifty cases. Direct violence in twenty-nine; indirect violence in twenty-one. Only in those cases where the injury was less severe did he get a perfect result.

He resected eight cases, in three of which there was complete restoration of function.

Philips and Gallard[6] report five cases of fracture of the neck of the radius, in which the Röntgen-ray examination revealed: "A fracture involving the posterolateral corner of the proximal juxta epiphyseal portion of the diaphysis of the right radius, the fracture entering the epiphyseal line, thus chipping off a pyramidal piece of bone measuring about one-half inch on a side." Apposition of the fragments was perfect except in one case.

All were treated conservatively with the arm held in Jones' position. Each case resulted in complete recovery of function.

Bohler[7] states: "If the head of the radius is fissured in its long axis, or is broken off without any displacement, it is treated by the application of a plaster bandage which is left on for four weeks, and in the same manner as the fractures of the olecranon. If the head is splintered and the fragments are displaced, or when the head is broken and dislocated, it is very seldom possible to obtain a good position. The rotations of the forearm are either quite limited or disappear altogether. In these cases, it is therefore best to remove the head. The incision is made on the lateral side but should not reach too far anteriorly, because small branches of the radial nerve are apt to be injured. A plaster case is given for two weeks."

Scudder[9] states that in fractures of the head and neck of the radius, in children: "The elbow should be placed in the acutely flexed position with forearm in complete supination after manipulative pressure and traction on forearm. Usually after ten days guarded painless motion may be begun and along with massage will succeed in securing almost perfect function of the joint."

In adults: "Excepting in linear fractures without much if any displacement, a complete removal of the head of the radius immediately after the injury should be done. All fragments should be carefully removed. Avoid injury to the joint capsule and synovial membrane. Keep the annular ligament intact. Close the wound tight. In about a week or less begin active guarded movements.

"In operating, the fragments of bone should be removed, and when the exact conditions are seen a complete resection of the head of the radius done. Operation is indicated with a complicating irreducible dislocation of radius or ulna or both.

"Gentle massage and passive motion and attempts at active motion should, within four to eight weeks, result in approximately normal elbow movements."

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END-RESULTS OF CARPAL-SCAPHOID FRACTURES

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The subject of this paper is a study of end-results of fracture of the carpal scaphoid, together with some remarks on the incidence of the fracture and on the probable manner of its production. This work takes origin in an analysis of case reports (with a study of the X-ray films and end-result examinations) in the Surgical Dispensary of the Episcopal Hospital of Philadelphia; from a dissecting-room study of the anatomy involved; and from a partial review of the literature.

The cross-index file in the Röntgen-ray department of this hospital for an approximate five-year period (January 19, 1925 to September 2, 1930), contains 125 instances of fracture of the carpal scaphoid. In about the same period of time, the following conditions were noted:

Fracture of the phalanges	716 cases	Luxation of the semilunar	19 cases
Fracture of the metacarpals	564 cases	Luxation of the os magnum	1 case
Fracture of the os magnum	2 cases	Luxation of the scaphoid	1 case
Fracture of the pisiform	3 cases	Subluxation distal row of carpus	1 case
Fracture of the semilunar	12 cases	Luxation of the wrist	9 cases
Fracture of the trapezium	3 cases	Kienboch's disease	1 case
Fracture of the trapezoid	1 case	Osteomyelitis of the carpus	2 cases

These figures place fracture of the carpal scaphoid third in order of frequency in fractures of the bones of the hand and wrist and demonstrate again that congenital anomalies, new growths and infections involving the bone in this region are rare.

The 107 cases of fracture of the carpal scaphoid used in this study, consecutive so far as it was possible to have them so, included ninety-five males and twelve females. Table I summarizes this group of cases which included those with and without follow-up study.

In forty-six of the 107 cases, an end-result study was impossible. In the remaining sixty-one patients, the final result was known, and in forty-eight of these, end-result X-ray films were available for study. The interval in the follow-up was above six years in seven; six years in eight; five years in three; four years in ten; three years in six; two years in fifteen and one year and under in twelve.

The end-results were classified as good, moderately good and poor. A good result was regarded as one in which all movements were normal, the grip had good power and there was no pain; a moderately good result was regarded as one having some pain but a good grip and normal movement, and a poor result was signified by pain of a more definite character, a limita-

TABLE I

107 Cases of Fracture of the Carpal Scaphoid (Ninety-five Males and Twelve Females)

Age†	Operative Cases	Old Cases	Causes of Fracture (Aside from a Fall on the Outstretched Hand to a Standing Level)	Associated Injuries	Site of Fracture*
Age 10 1 2nd decade 24 3rd decade 32 4th decade 30 5th decade 7 6th decade 7	5 (all from the group of old cases)	16 (more than two weeks)	1 struck on wrist by hammer 1 struck on wrist with iron bar while hand was in midair 2 crushing injuries 2 fell from motor trucks 2 from backfire in cranking an engine 1 from lifting a heavy object 8 fell a distance equal to or exceeding their height	8 dislocations of semilunar (all volar) 1 fracture of semilunar (not dislocated) 1 dislocation of distal carpal row 5 fractures of distal end of radius (3 of which were comminuted) 1 chauffeur's fracture 1 incomplete fracture of radial head 1 Colles' fracture 1 fracture of the cuneiform 1 fracture of proximal end of first metacarpal 1 fracture of ulnar styloid 1 compound fracture both bones of forearm at the junction of the middle and lower thirds with a sprain fracture of the ulnar styloid and the cuneiform	73 middle of bone (all transverse) (7 incomplete) 7 distal end (5 in region of tuberosity and 2 through distal radial corner) 2 in proximal end 2 along posterior border 4 comminuted 6 had fragments dislocated (in every case in volar direction) 2 had two fractures in bone (one in middle and one in distal end in each case)

* The site of fracture in the bone is given in the above tabulation in those cases where the film was at hand or where the X-ray report stated definitely the location of the fracture.

† Age is given in Tables I and II at time of fracture and when definitely known.

tion of movement in the wrist-joint, and a weakened grip. With this classification in mind, forty were found to be good results, ten were moderately good and eleven were poor. This group is summarized in Table II.

The two patients with comminuted fractures who fell in the end-result group obtained a good result, one with operation and one without. In two fractures with displacement of fragments, in each case the distal fragment being the one displaced, the result was good, but the end-result X-ray film showed slight deformity of the scaphoid in one. The seven patients with fracture in the distal end and the two with fractures along the posterior border had good results. Unfortunately, the two patients with fractures in the proximal end and with two separate fractures in each bone belonged to the group of cases without end-result study. Four of the seven cases with incomplete fractures were in the end-result group and all showed an excellent result clinically, and by X-ray examination.

There were no bipartite scaphoids found in this series, nor was a single case of cavity formation found. Likewise, there were no instances of ex-

TABLE II

End-Results in Sixty-one Patients with Fractured Carpal Scaphoid

	Ages in Years	Patients Operated on	Old Fractures (of More Than 2 Weeks' Duration)	Associated Injuries
Good Total = 40	2nd decade = 13 3rd decade = 11 4th decade = 9 5th decade = 6 6th decade = 1	2	5	Three volar dislocations of semilunar One fracture of distal end of semilunar One sprain fracture of ulnar styloid
Mod. Good Total = 10	14, 20, 21, 25, 27, 29, 38, 48, 50, and 51 years, respectively		4	One compound fracture of both bones of forearm with a fracture of ulnar styloid and cuneiform bone One sprain fracture of lower posterior border of radius
Poor Total = 11	17, 18, 18, 19, 21, 21, 23, 33, 36, 39, and 67* respectively	3	6	Two volar dislocations of the semilunar

* The 67-yr.-old patient was fractured an unknown number of years previously.

trinsic synostosis to the articular margin of the radius as described by Bizarro.[2] The increased percentage of associated injuries in the poor and moderately good result groups was thought to be significant only of the increased force which acted.

In discussing this series of fractures, it can be pointed out that fracture of the carpal scaphoid is a fracture occurring in the first half of life and that it is comparatively rare above the age of fifty. The statement sometimes made that age has little to do with the prognosis in this type of fracture does not convey all of the truth.

The question of correlation between the clinical end-result and the end-result X-ray film has been mentioned in the literature and it is answered in the negative in the case of the patient, V. G., aged thirty-nine years, having a three-year-interval follow-up. At the age of thirty-six years, this man fell to the ground and sustained what was diagnosed as a slight subperiosteal fracture of the scaphoid. His end-result X-ray film, taken in August, 1931, showed an excellent result with no sign of the previous fracture, but on clinical examination, crepitus could be felt in this wrist and there was some weakness in his grip. This case, however, is the only one classed as a poor result in which the X-ray findings were not what one would expect to find with opinion based on the clinical examination.

In the group of moderately good results, one man, F. T., aged fifty-seven, showed nonunion with arthritis on X-ray examination but his grip was powerful, and radial deviation and flexion and extension only slightly limited, six years after the fracture. Another

patient, S. B., aged twenty-eight years, fourteen months after fracture, showed an excellent union in the X-ray film with no line of fracture visible, but on clinical examination extreme dorsiflexion was painful.

In the group of good results, a patient, H. S., aged thirty-one years, after two and one-half years' interval, showed a good clinical result but the X-ray film showed non-union without arthritis. A patient, R. L., aged twenty-six years, after a three-year interval since fracture showed a good clinical result, but X-ray examination revealed an ununited fracture with considerable atrophy of fragments. There were two patients classified as good results in spite of the fact that they had very slight pain when using the wrist in a certain fashion; one complained that he felt pain when he walked on his hands and the other had pain only in pitching a baseball. The above-mentioned cases taken from each of the three end-result groups seem to indicate an occasional discrepancy between the end-result clinical and Röntgen examinations.

The rarefaction of the scaphoid and other carpal bones following this fracture may be due, in part, to the direct injury, and, in part, to the atrophy of disuse caused by the pain on movement or to the splint used in the course of treatment. This brings us to a very live question which is involved in any study such as this, *i.e.*, Is traumatic arthritis an example of hypertrophic or atrophic arthritis? A patient, E. F., fell at the age of fourteen years and sprained his wrist. Nineteen years later, at the age of thirty-three years, he came to the Dispensary complaining of pain in his wrist. Clinical examination showed some limitation of movement in all directions in the wrist with slight grating. The X-ray examination showed non-union in an old fracture of the carpal scaphoid with hypertrophic osteoarthritis of the distal border of the radius. Another patient, J. G., aged eighteen years, fell two years and seven months before, and sustained a transverse fracture in the middle of the scaphoid bone with volar dislocation of the semilunar. He was operated on five months after the injury and one-half of the scaphoid and the semilunar were removed. His last clinical examination (1931) showed limitation of dorsiflexion and of radial and ulnar deviation, with some weakness of the grip, and with a complaint of pain in bad weather. Röntgen examination showed traumatic arthritis of the wrist with lipping. In these two patients, one sees the development in young adult life of a disease ordinarily found in older individuals. In all other cases in this series showing signs of arthritis, the findings were those of the atrophic type, *i.e.*, with limitation of motion and rarefaction, loss of sharp bone outline, and absence of lipping in the röntgen examination.

One might think of the wrist-joint as being functionally older than many other joints in the body for it is nearly always in motion in our waking hours. A. W. Meyer[7, 8, 9] has written very interestingly of use degeneration in normal joint cartilage. This idea of the individuality of joints seems to gain support from studies by D. H. Kling[6] on the Nature and Origin of Synovial Fluid, who wrote: "The development of the membrane and of the fluid is different in various joints. The secretory element is best developed in the knee-joint and less well developed in the wrist and tarsal joints. The primary response to inflammation and irritation of the knee is, therefore, effusion; that of the wrist, infiltration and pannus formation."

The treatment of recent cases (two weeks old or less) in this series, has been by a straight volar splint from the base of the fingers to the elbow for not less than five weeks and longer if necessary. The splint is reapplied once a week. Berlin[1] dissected sixty wrists and thought that some of the flexor tendons with the transverse carpal ligament acted as a sling to hold the fragments of the scaphoid in closer apposition in moderate dorsiflexion, and that the attachment of the dorsal carpal ligament to the proximal two-thirds of the dorsal surface of the scaphoid made any other position but

dorsiflexion illogical. He advocated dorsal flexion to about 40 to 50 degrees with slight radial deviation Böhler[3] also advised dorsal flexion, using a dorsal plaster splint, and he is very optimistic over the prognosis even in old cases when this treatment is continued for a longer period. Speed[10] advocated a position midway between flexion and extension.

Hosford[5] reported nine good results out of twenty-six fractures and Burnett[4] reported seventeen good results; thirteen fair, and seven poor. Both of these men used the dorsiflexed position. If a stiff wrist is anticipated, dorsiflexion seems to be the position of choice for splinting. In many of the old cases in adults, it should be remembered that one is dealing with an arthritis and while operation may be performed in the older cases, and seems to be indicated early in those cases with displaced fragments, the prognosis should be guarded.

The opinion may be ventured that fracture of the carpal scaphoid without displacement, in which splinting is instituted within a few days and continued for a period of from five to eight weeks, warrants an optimistic prognosis; certainly as optimistic as for intra-articular fracture elsewhere in the body.

A SUGGESTED MECHANISM IN THE FRACTURE OF THE CARPAL SCAPHOID

This discussion is concerned with the production of fracture of the carpal scaphoid in the ordinary manner, which is by a fall on the hand or by backfire in cranking an engine. Forced hyperextension of the wrist is not considered here because it is probably not of common occurrence in falls on the hand. The weight of the body in the average fall is received on the muscular volar-superior surface of the hand. This statement is supported by two observations, the first of which is found in the occasional clear history of a fall forward on the hand where forced hyperextension would be unlikely; secondly, it seems reasonable to assume that the very capable protective mechanism which exists proximal to the wrist in the shoulder, elbow and proximal radio-ulnar articulations would be utilized to the limit before hyperextension occurred. In the shoulder-joint, this is composed of a possible 135 degrees of rotation of the trunk around the head of the humerus, combined with circumduction of 360 degrees, when the position of the hand is fixed and the radius and ulna are fixed on the humerus. After the force of the fall is taken up in the hand, the elbow-joint may relax, allowing the body to roll forward or backward of the coronal plane to the ground. Moreover, when the trunk is fixed on the head of the humerus, the humerus may still rotate 180 degrees around the head of the radius, and any or all of these movements may take place together.

The wrist-joint, of which the scaphoid forms somewhat less than half of the distal articular surface, is a biaxial diarthrosis allowing flexion and extension of about 50 and 75 degrees, and ulnar and radial deviation of about 40 and 25 degrees, respectively. Full ulnar and radial deviations, present only when the wrist-joint is in 180 degrees extension, become progressively less as the wrist goes into extension, until they are absent in hyperextension.

This is readily understood when it is remembered that the axis of rotation in ulnar and radial deviation is an antero-posterior line through the centre of the carpus, when the wrist is at 180 degrees extension, but which would change to a superior-inferior line through the centre of the carpus, were rotation possible when the wrist was hyperextended. But this is not the case, and if it were, then rotation in the wrist would be possible in three planes instead of two as it normally is, and the wrist would thereby become an enarthrosis with the movement polyaxial. This may be checked on the cadaver by taking the forearm, disarticulated at the elbow, with the hand fixed in radial or ulnar deviation, and gradually bringing the proximal end of the specimen up from a position of 180 degrees extension into hyperextension. While using all possible force to press down on the proximal end of the radius and, at the same time, attempting to hold it over into either ulnar or radial deviation, it will be found that the radius is rotated from distally, in the radiocarpal articulation, out of deviation into the mid-position. Again, with the forearm disarticulated at the elbow, the body weight of the investigator was thrown forcefully against the proximal end of the radius, with the hand fixed in radial deviation and as much extension as the deviation would allow. The result was a fracture of the radial styloid.

In the disarticulated specimen of the wrist-joint, it is apparent that the articulating surface of the joint is longer than it is wide; that it is incongruent in any other position except the one; and that in hyperextension it is locked in this position by the overhanging anterior lip of the articular surface of the radius. Furthermore, the flexor carpi ulnaris and the flexor carpi radialis when put under extreme tension, as in hyperextension, serve as ligaments to check movement in this joint.

In the dissected specimen of the wrist with only the intercarpal ligaments intact, it will be found that the bones of the proximal row of the carpus form an arch which is curved in two directions. It is convex on its radial and dorsal surfaces, respectively, and concave on its midcarpal and volar surfaces, respectively. It is noteworthy that the scaphoid bone comprises almost one-half of this arch of proximal bones and that the radial side of the arch is not segmented as it is on the ulnar side, where the osseous elements are divided into two separate bones (semilunar and triangular). The scaphoid is narrowed at its middle, and on the dorsal surface across its midportion is attached the dorsal carpal ligament, through which small blood-vessels enter the bone. At either extremity the arch rests on the multangulars and on the hamate, and is supported in its middle by the head of the capitate. The distal row of bones are firmly bound to each other and to the proximal ends of the metacarpals, and except in the case of the first metacarpal, may be considered as a unit for there is scarcely any movement between them. Their ligaments are very strong and dense. Force transmitted from the distal row of carpal bones, where most of the force from a fall on the hand probably originates, reaches the scaphoid by three routes; one through the capitate, which fixes the scaphoid against the articular surface of the radius;

one line of force on the radial side through the multangulars to the scaphoid on its distal end, and one on the ulnar side through the hamate, triangular and semilunar to the proximal end of the scaphoid. The semilunar is the keystone of this arch, which accounts for its rather frequent dislocation.

The structure maintaining this arch is the transverse carpal ligament and its position of importance in the explanation of these fractures and in the normal use of the hand has not been sufficiently recognized. This exceedingly strong ligament spans the concavity of the volar surface of the carpus and converts this concavity into a tunnel for the passage of the deep flexor tendons and median nerve. It is attached on the radial side to the tuberosity of the scaphoid, and to the scaphoid bone around the base of the tuberosity, and to the ridge on the volar surface of the greater multangular bone which lies just radially to the groove in the bone for the flexor carpi radialis tendon. On the ulnar side, it is attached to the triangular bone with an attachment passing to the pisiform and to the unciform process of the hamate bone. These four bony attachments protrude volarly and serve to accentuate the concavity anteriorly, of the proximal row of bones. It is interesting to note that the two strong flexors of the wrist pass directly over these bony prominences, and in the palm down position of the hand as in falling, lend support to them. The flexor carpi radialis lies directly against the volar surface of the tuberosity of the scaphoid, with its sheath much thickened at this point, and then passes in a groove on the surface of the greater multangular on its way to insertion in the proximal end of the second metacarpal. The flexor carpi ulnaris inserts on the pisiform which lies on the volar surface of the triangular, and then is continued to the hamate by the piso-hamate ligament and to the base of the fifth metacarpal. The pisiform bone is not of importance when discussing the proximal row of carpals as an arch in a superior-inferior direction. However, when considering the arch which these bones form in the antero-posterior (volar-dorsal) direction, the pisiform assumes new value for it supports the ulnar side of the arch when the hand is in the position which it assumes in transmitting pressure instead of tension, *i.e.*, in a fall on the hand, or in pushing with the hand, or in sustaining pressure from the backfire of an engine.

As the wrist moves into extension, the tendons of the flexors carpi ulnaris and radialis are put on the stretch and support this arch of the proximal row of bones. This seems to be an ingenious arrangement on the part of Nature, to transform the pressure of a fall into a tension in the tendons of the flexors carpi ulnaris and radialis, and so transfer the force all through the hand, from the base of the second metacarpal on the radial side and the base of the fifth metacarpal on the ulnar side, to the proximal row of carpal bones and the articular surface of the radius. The arrangement may be compared to an inverted suspension bridge in each tendon, where the head of the second metacarpal and the hamate and the base of the fifth metacarpal, serve as anchorage for the two tendons, and the pisiform against the triangular on one side, with the tuberosity of the scaphoid and the ridge on the greater

multangular on the radial side, acting as suspension towers which hold up the arch of the carpus. The transverse carpal ligament prevents the tendency to spread apart of the extremities of the arch when pressure is applied to its convexity.

When one falls on his hand, the semilunar is pushed straight downward, sometimes slipping out into volar dislocation, while the triangular and the scaphoid are forced lateralward. The middle of the scaphoid is the weakest point in this arch of the proximal bones for three reasons; first, it is thinnest in its middle; secondly, the cortex, which is the only hard bone found in any of the carpals (the interior being cancellous), is perforated by small vessels in this area; and thirdly, the scaphoid is the largest and longest bone in the proximal row, and is not segmented, and therefore is less able than the osseous elements on the ulnar side of the wrist to withstand a fracturing force. The proximal end of the scaphoid is held against the articular surface of the radius by the capitate. The transverse carpal ligament, by its attachment to the distal end of the scaphoid and to the greater multangular to which the scaphoid is also attached, resists this lateral expansion of the carpus and fracture in the middle of the bone is the result.

Due to its position, injury to the tendon and its sheath of the flexor carpi radialis where it passes over the tuberosity of the scaphoid may account for some of the pain in these wrists, where the X-ray examination is negative and where the clinical examination is otherwise negative.

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RECONSTRUCTIVE OPERATION FOR NON-REDUCIBLE FRACTURES OF THE HEAD OF THE HUMERUS

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from the surgical service of menorah hospital

There are no fractures in which the prognosis for recovery of function is more grave than in those about the surgical neck of the humerus, when accompanied by fragmentation and gross displacement. If dislocation of the fractured head is present, the outlook is even more gloomy.

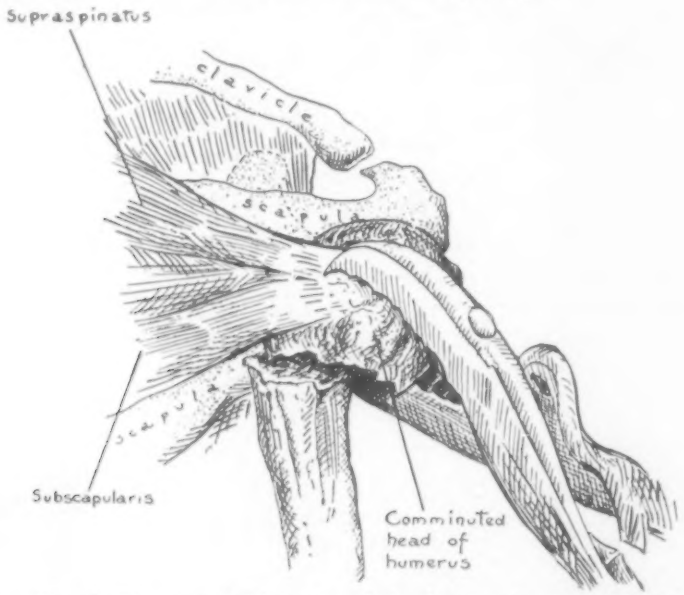


Fig. 1.—Diagrammatic illustration of the first step in removal of the fractured head and the attached short rotators of the humerus.

Although this particular sub-group probably does not contain more than 2 per cent. of the total number of fractures in this region, the poor results of treatment impel me to report an operative procedure first used by me in 1926, the final results of which have exceeded my most sanguine expectations.

The literature abounds with analyses of end-results of varying forms of treatment. A quotation from Santee[1] affords an excellent and characteristic example. "End-results in these cases (the severe fractures requiring operative reductions and excisions of the head) are little different from those cases in which no operation was done. Fractures about the neck of the humerus occur mostly after mid-life; disability is marked and prolonged."

The operation about to be described is not suitable for gross defects involving the entire upper third of the humerus. Various procedures using bone-grafts have been reported by De Courcy Wheeler,[2] and Albee[3] for this

type. One quotation from Albee[3] should be noted: "From the stand-point of definitive treatment such cases have been regarded as quite hopeless. The arm is merely a cumbersome appendage which might, occasionally, be swung laboriously from one side to the other in the performance of simple clumsy acts, but which, from a practical stand-point, is useless."

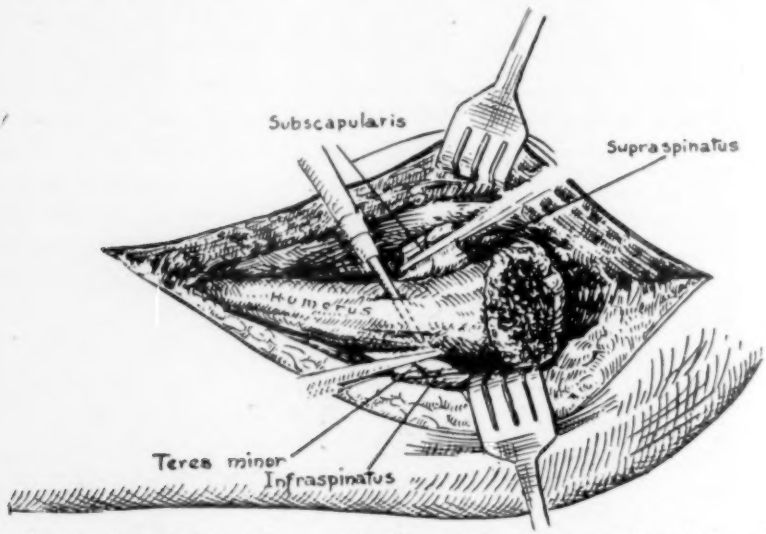


FIG. 2.—Demonstrating tendons of the four rotators and preparation of site of transplantation.

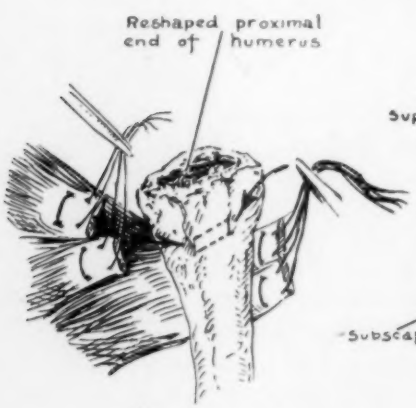


FIG. 3.

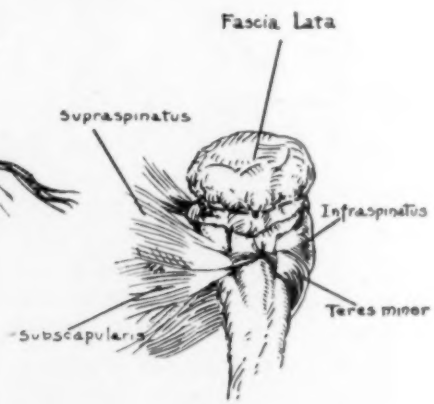


FIG. 4.

FIG. 3.—Diagrammatic illustration of reshaped head and tendinous preparation.
FIG. 4.—Diagram illustrating the application of the fascial flap and the completed muscle transplants.

Murphy,[4] in several cases, removed the fractured head, reshaped it and then drove a nail at an angle through the shaft into the head. He accompanied this by a fat or fascial transplant.

Present-day treatment has been limited to resection of the head, or arthrodesis. Where fusion of the humerus to the glenoid is performed, scapular motion sometimes compensates very well for the lost shoulder-joint motion

but abduction is limited to twenty degrees at most and there is almost complete loss of rotatory movement.

Description of the Operative Procedure.—There are two points to be considered before the operation. One, the preparation of an æroplane splint designedly about two inches shorter than the normal upper arm length, adjusted at about a 50° angle from the vertical, the other, a special operative assistant, seated at the side of the table, to control the arm through manipulation of the elbow. This is absolutely essential to proper exposure. From a previously prepared area on the thigh, a circular strip of fascia lata, measuring

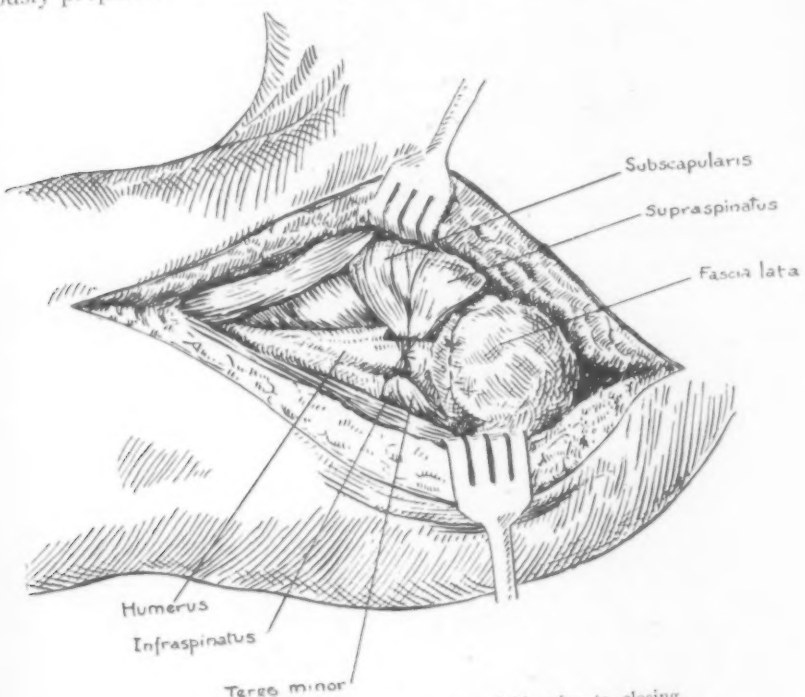


FIG. 5.—Appearance of operative field prior to closing.

about three and one-half inches in diameter, is secured. It is then placed in saline solution. An eight-inch lateral incision is made, starting one and one-half inches above the acromion processes, and extending down the arm.

At the present time, I am of the opinion that an anterior approach would be a better one. The incision is deepened, the joint capsule incised and the fractured head of the humerus exposed. The head is seized with large bone forceps, separated from the shaft and surrounding structures, and forcibly drawn out of the wound. Two grooves are made in the shaft of the bone, about one-half inch apart, and about one inch below the upper end of the shaft and connected to each other by a small tunnel.

This was the procedure used in the second case from which the drawing was made.

The operation was performed with slight modifications each time.

To secure the closest resemblance to the normal anatomical position, two drill holes should be made, one antero-posteriorly, the other laterally.

The short rotators attached to the head: namely, the supraspinatus, the subscapularis, the infraspinatus, and the teres minor, are cut close to their

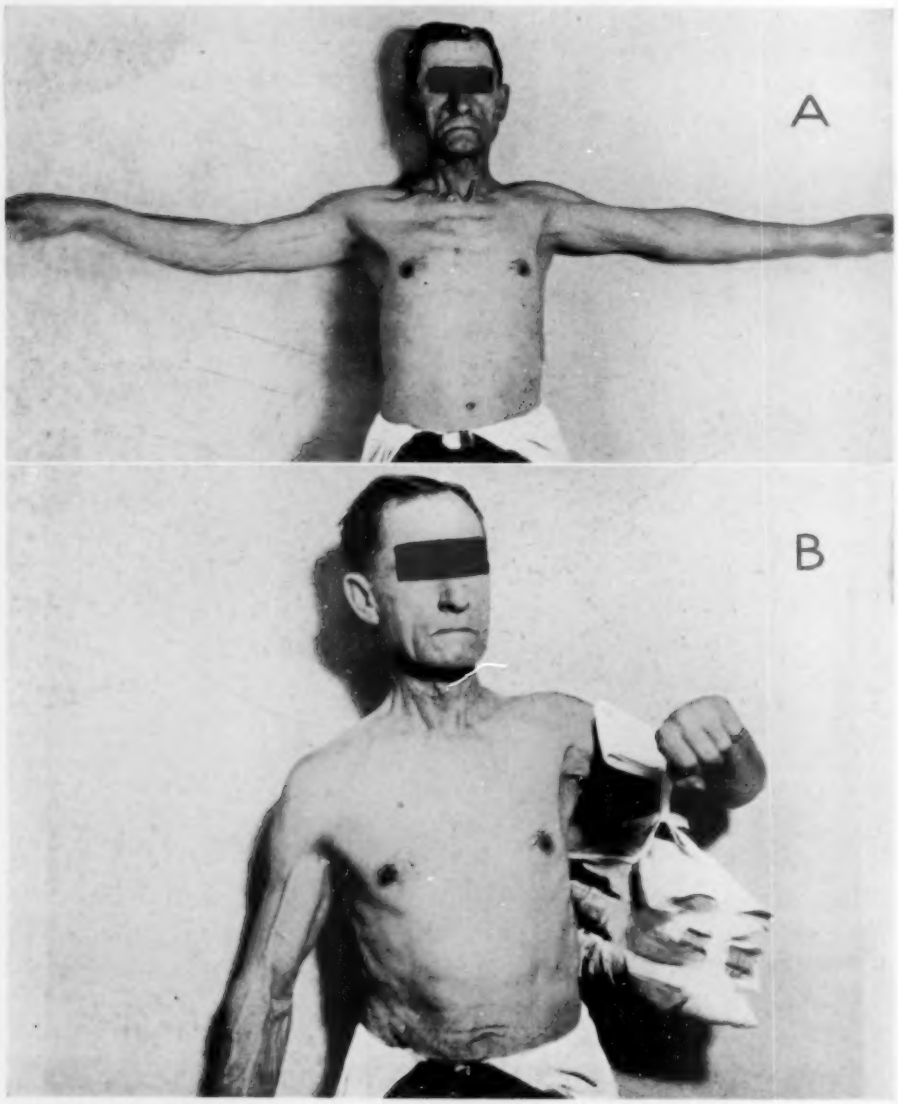


FIG. 6.—A—Showing full abduction possible. B—Showing restoration of function.

points of insertion, and figure-of-eight silk sutures fixed in the ends of each tendon. The head now being resected, the shaft of the humerus is brought through the incision by the operative assistant. The rough surfaces are rounded off with a rongeur, bone-cutting forceps, file, *etc.*, and the fascia lata transplant applied over the end with a purse-string suture. The tendons are

then drawn into the grooves, and the sutures tied to each other. Although it might seem that there would be confusion in the insertion of the tendons, actually there is none as the tendon of the subscapularis naturally falls into the anterior opening, the supraspinatus into the lateral, and those of the infraspinatus and teres minor into the posterior. The tying is performed in such a manner that the upper end of the reshaped shaft fits snugly into the glenoid cavity. The various layers of the wound are closed in the usual manner.

The experience of the present reporter, upon which the following observations are based, is as follows:

CASE I.—July 15, 1926, a carpenter, aged sixty-seven years, fell from a scaffold, striking his left shoulder against a timber. He was immediately taken to the hospital. Because the left shoulder was flattened as compared with the right, his physician made a diagnosis of dislocation. No röntgen examination was made at that time. A Kocher manipulation was performed under anæsthesia. When it was found impossible to reduce the deformity, a röntgen examination was made which showed that the patient had a fracture of the surgical neck, with a subglenoid dislocation of the head. Both the head

FIG. 7.—(Case II.) Pre-operative X-ray.

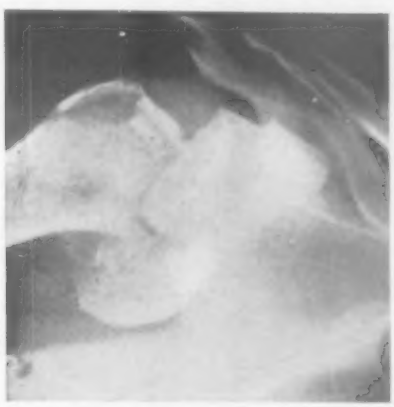


FIG. 8.—(Case III.) Pre-operative X-ray.

and neck were widely comminuted. This röntgenogram was inadvertently destroyed following the fire scare of several years ago. I was called in consultation the following day, and July 17, 1926, the operation presently to be described was performed.

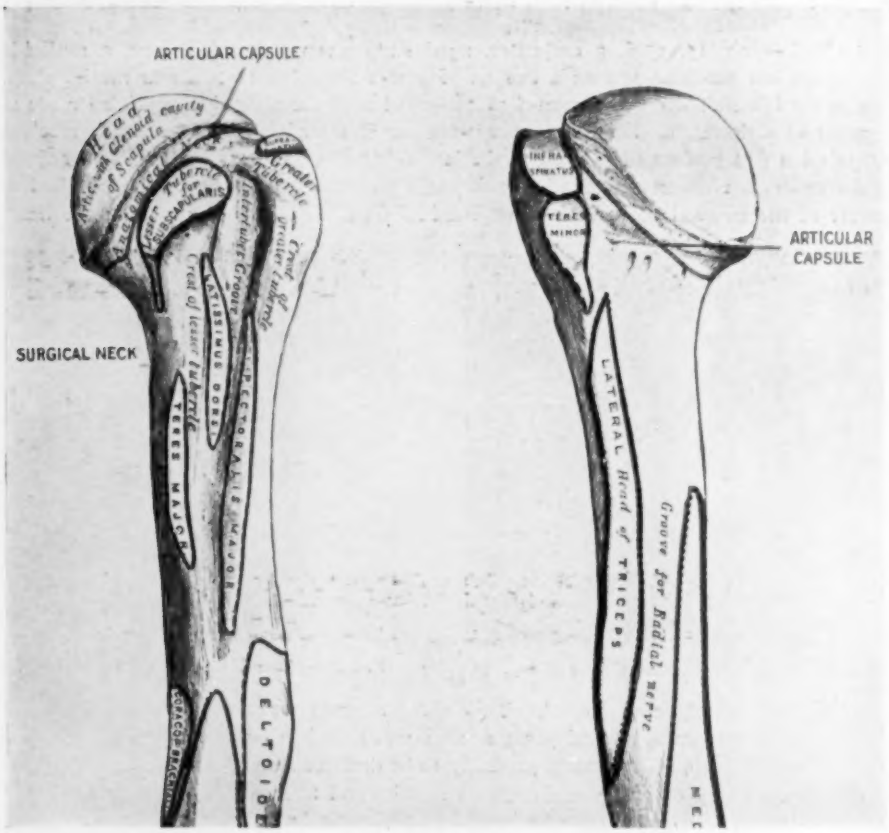
It was necessary on two occasions, two months and five months later, respectively, to manipulate the arm under anæsthesia to free peri-articular adhesions. At the end of six months he was able to return to his work as a carpenter. At the present time, although seventy-two years of age, he is working every day as a janitor at the City Hall, washing windows, sweeping, *etc.* The injured shoulder is as stable as the uninjured. He can carry twenty-five pounds of sandbags with the arm in full abduction.

CASE II.—October 16, 1930, the patient, a mechanic for the City Water Department, fell a distance of about ten feet, from a ladder. He believes he fell directly on the point of the left shoulder. He was fifty-eight years old, not particularly robust, in considerable pain and slightly shocked. The curve of the left shoulder was flattened as compared with the right, and he was unable to move the arm at the shoulder-joint. A röntgenogram demonstrated a comminuted fracture of the upper end of the left humerus at the junction of the head and neck. The greater tuberosity was also comminuted. The upper end of the lower fragment (the shaft) was displaced into the axillary space. Under gas-oxygen anæsthesia, abduction was attempted. A plaster bandage was applied to the

chest, in which was incorporated a metal device for extension of the arm in partial abduction.

The laboratory reported a strongly positive Wassermann, and the following blood count: Hæmoglobin, 70 per cent.; red blood-cells, 3,530,000; white blood-cells, 16,000. He was placed immediately on iodides, and bi-weekly intramuscular injections of one cubic centimetre of bismuth subsalicylate.

Other attempts at reduction, both by manipulation, increasing traction, and changes in splint position, were ineffectual. His general condition had improved, and he had received enough therapy to control his lues, so November 14, 1930, operation was per-



FIGS. 9 AND 10.—Illustrating points of insertion of "short rotators." (After Gray.)

formed. The post-operative course was somewhat stormy. His secondary anæmia became grave, finally resulting, November 25, in a hæmoglobin of 50 per cent., a red blood-cell count of 2,790,000. An indirect citrated blood transfusion of 500 cubic centimetres was given, and the same anti-luetic therapy previously mentioned was resumed. His condition rapidly improved, and he was discharged from the hospital January 6, 1931.

At the present time, he can abduct the arm to an angle of 50°, and carry a sandbag weight of 10 pounds at that angle. Rotation is limited to one-half the normal range of motion. He has returned to work.

CASE III.—February 20, 1932, a housewife, aged sixty-one, fell striking her shoulder directly on the pavement. Following the accident, she was unable to use the arm. A röntgenogram showed a complete transverse fracture at the anatomical neck of the humerus, with the head lying anteriorly and below the sub-coracoid process. There

was comminution of the upper fragment. The patient was considerably overweight and her physical condition did not admit operation until March 5th, when the above procedure was performed.

Four months after operation, the patient can abduct to fifty degrees, has two-thirds the normal rotatory range and can carry a ten pound sand-bag with the arm abducted forty degrees.

FIG. 11.—Case I. Post-operative X-ray.

FIG. 12.—Case II. Post-operative X-ray.

DISCUSSION.—If the results of this operation are considered as experiments in muscle physiology, they prove one point to my entire satisfaction. Up to this point, these transplanted muscles have been referred to as the short rotators as that is their accepted name. I do not believe that is their major function. Rather are they suspensory muscles, whose chief action it is, with the arm abducted, to hold the head of the humerus firmly against

FIG. 13.—(Case III.) Post-operative X-ray.

the glenoid, where the more powerful flexors and extensors, such as the pectoralis major, latissimus dorsi, etc., can exert their full force on a firm base. The usual anatomical plates and descriptions give us an erroneous impression.

In some no mention whatsoever is made of the relationship of the tendons to the capsule. In others, the description of the insertion is accompanied by

such phrases as "fibers are intimately adherent to the capsule" or are "reflected to the capsule." In Cunningham, Morris and Piersol, they are described as if they had a double insertion. For example, "The subscapuloris inserts (1) into the small tuberosity of the humerus (2) the front of the

FIG. 14.—Case I. Post-operative X-ray. Arm in abduction.

FIG. 15.—Case II. Post-operative X-ray. Arm in abduction.

capsule of the shoulder-joint." Actually, the tendons of these four muscles are inserted into the capsule about one-half inch from the final bony insertion and fusing with the capsule, are then inserted into the semicircle extending from the anterior edge of the lesser tuberosity to the posterior edge of the

FIG. 16.—(Case III.) Post-operative X-ray in abduction.

greater tuberosity. They cannot be dissected free from the capsule and are a part of it.

Doctor Codman once expressed this aptly by saying "The muscles of the shoulder-joint are the capsule." Against the fact that rotation is a major component of their action is first, their insertion into the extreme end of the humerus and secondly, the diffuse manner by which they inert into the capsule. An argument for their basic suspensory action is the fact that,

with all the other muscles removed, when these muscles are cut, the head of the humerus drops away from the glenoid.

Further support to this view is given by a study of the post-operative röntgenograms in these cases. Never was the apparently paradoxical axiom frequently quoted by Dr. Robert W. Lovett better illustrated. The statement was "The bones are held together by muscles, not by ligaments." In support of this assertion, this example was frequently given. A child, following poliomyelitis, has, as an end-result, paralysis of the gluteal muscles. The ligaments of the hip-joint, deprived of the secondary support derived from the enveloping musculature, gradually elongate. Six months to a year later spontaneous dislocation occurs. In all the reported cases here, the shaft is seen lying at the lower margin of the glenoid cavity with a large space between its upper end and the acromion processes, in apparently imminent danger of dislocation into the axilla should the arm be abducted. But so surely do the transplanted muscles function that tests made on the operated side demonstrate no more play than in the normal unoperated shoulder-joint.

Further, X-rays taken with the arm in abduction show that the head of the humerus is pulled securely into the glenoid and that there is no separation in this position. It is also interesting to note how nature, under the stress and strain of functional use, builds up on the inner and upper surface of the bone, a structure which closely approximates a new head.

In all these cases, no attempt was made to plicate the joint capsule. It is then permissible to speculate that, if extreme stability can be obtained under such adverse conditions, then instability may be due to the same factors acting conversely. In other words, lengthening of these muscles may be the cause of secondary relaxation of the joint capsule. An attempt will be made to decide this point by a study of the relationship of muscles to capsule in the presence of habitual dislocation of the shoulder-joint.

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ELEPHANTIASIS NOSTRA*

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Elephantiasis, called Herculasian disease by the ancient Greeks, has always been a very spectacular affection. Up until the Middle Ages, as Virchow[1] tells us, it was often confused with leprosy due to its similarity in certain phases with the tissue hypertrophy of lepra. Just as the man with elephantiasis was banished from society by certain ancient people who thought him to be a leper, so did certain African tribes make saints out of the victims of this disease because they thought it a special favor of the gods to have a much enlarged scrotum or leg. Even today in more civilized countries we often see an elephant man exhibited in a circus or side show. Sir Frederick Treves[2] has written a vivid and sad story of an elephant man.

Up to the beginning of this century elephantiasis was a medical curiosity and the only rôle the surgeon played was to undertake the last step of amputating the affected part when it threatened to become larger than its owner. With the rapid rise of surgery this disease has received its share of attention and many different operations have been devised.

For the proper understanding of the treatment one must know first the nature and cause of this disease. As we will see subsequently there is only one elephantiasis but there are innumerable causes for it. Elephantiasis is a chronic inflammatory fibromatosis of the dermal and hypodermal tissues, either preceded or accompanied by venous and lymphatic stasis. Mere venous and lymphatic stasis will not produce true elephantiasis; there must be a second element which is the infection. In the past twenty years there has been much controversy as to the rôle lymphatic obstruction and infection play as etiological factors. Matas[3] believes both are of equal importance. Unna[4] and Saboroud[5] believe that infection alone by the streptococcus can produce elephantiasis. Kuntzen,[6] who writes from Payre's clinic, believes that lymphatic obstruction plays the major rôle, the erysipeloid streptococcal infection being secondary and acting only to intensify the course of the disease.

According to the numerous causes we could classify this disease into many varieties. In order to avoid confusion, however, we can distinguish between the elephantiasis which is caused by the filaria and that which is not. In the true filarial elephantiasis the lymph channels are obstructed by the parasites, thus producing fertile soil for the invasion of the streptococcus. It is now generally recognized that the tropical elephantiasis is frequently not

* Read before the Philadelphia Academy of Surgery, April 4, 1932.

caused by filaria. The reason for the greater frequency of elephantiasis in the tropics is the greater exposure of the skin to infection.

In northern latitudes the disease is most often called elephantiasis nostra, distinguishing it from the tropical variety, but there are authorities who give the by-name of nostra only to those cases in which no apparent cause can be detected. Any factor, such as an injury involving the circumference of a limb at its root, or tumors, be their origin carcinoma, tuberculosis or syphilis, involving or pressing on the lymphatics, may ultimately cause elephantiasis, by causing lymphatic stasis. Very often a phlebitis or an inguinal bubo or the cicatricial contraction after herniorrhaphy will with a superadded streptococcal infection produce the disease. In certain cases as for example Milroy's disease, heredity must also be considered an important factor in the etiology. Then we have the true surgical elephantiasis which follows radical breast amputations, and which Halstead[7] believes is due to infection of the flaps at the time of operation, but which many others believe is nothing but a sign of the recurrence of the malignancy. Kuntzen, who has studied forty-seven cases of the non-tropical variety, includes under the heading of genuine elephantiasis nostra only those cases which begin insidiously in young people at the age of puberty and in which the disease always involves the lower extremity or the external genitalia. It is his belief that because it begins at puberty or occasionally near pregnancy that there is some endocrine factor involved in its production. Kuntzen further emphasizes the localizing element in these cases. As the lymph flows by muscular and valve action the hydrostatic element in the production of this disease is very evident. It is seldom that we find elephantiasis nostra in other than the dependent parts of the body, such as leg, scrotum, or penis. Concerning the rôle of infection, Kuntzen, after careful study of his forty-seven cases, found that in only one case did the typical erysipeloid attack precede the lymphœdematous swelling. He believes that the erysipeloid infection has nothing to do with the cause of elephantiasis but that it is of grave importance for the subsequent course of the disease. It is our belief that without the erysipeloid attacks there may be lymphœdema but there cannot be that true fibromatosis so characteristic of elephantiasis.

A very interesting study of sixty cases of elephantiasis has been made in Porto Rico by Suarez.[8] He took cultures from what he believed to be the infectious foci of ten cases and got nine positive cultures of hemolytic streptococcus and hemolytic staphylococcus. On the other hand, he took fifty cultures from the tissues of the affected limbs and got only one positive culture.

The typical course of elephantiasis might be described as follows: Recurrent attacks of elephantoid fever, with chills, a temperature around 103°, general malaise, a painful red swollen limb, with enlarged regional lymph-nodes, the entire picture very closely resembling erysipelas. In fact, one of our cases was first treated as erysipelas. After from two to eight days the fever subsides and the patient feels well but the swelling of the part does

not disappear entirely. After about a year or a few months seldom oftener than every month the attack will recur and the swelling subsides less each time. The dermal and hypodermal tissues will hypertrophy and the underlying soft tissues will unite with the skin to form one brawny hard induration and the typical elephantoid proportions will develop. The whole process extends over a period of years and once the erysipeloid habit is developed it will not stop until the elephantiasis is fully developed. There are certain cases where the constitutional symptoms are lacking, but when these patients are carefully questioned they always remember their attacks of redness and swelling. In a fully grown elephantiasis one observes a pillar-like extremity or a scrotum as big as a head. The skin is hard, does not fold or pit, and shows certain trophic disturbances such as nail changes, hyperkeratosis and scaling. Occasionally there will be ulcerations with considerable lymph drainage. The microscopical picture shows a typical hypertrophy of the skin and subcutaneous tissue with an increase in the collagen bundles. The deep fascia is often very much thickened. The vessel walls are hypertrophied and show considerable perivascular round-cell infiltration. The lymph-vessels themselves do not show much change. Interesting and of great importance for the success of the surgical treatment is the fact that the tissue hypertrophy and sclerosis stops with the deep fascia. The disease involves only the structures of the superficial venous and lymphatic system.

The diagnosis of elephantiasis is rather simple. It is easily differentiated from leprosy because the latter is a systemic disease of slow progress and long standing. Recently, Reichert,[9] of San Francisco, and Golden, in Porto Rico, have taken soft-tissue X-rays and they find a very marked dense trabeculation of the soft parts and in the case of filarial elephantiasis they find the calcified filaria.

The treatment of this disease should be both medical and surgical for each one of them alone does not produce very permanent results. The medical treatment consists of:

(*a*) Baking and massage (usually pre- and post-operatively).
(*b*) Elevation of limb (usually pre- and post-operatively).
(*c*) Compression of limb by elastic bandages.
(*d*) Injection streptococcus polyvalent serum.
(*e*) Vaccine therapy.
(*f*) Fibrolysin.
(*g*) Foreign-protein therapy (typhoid, aolin, and whole blood).

There are several cases reported in the literature, especially in more recent times, which have been treated very successfully with vaccine and anti-streptococcus serum alone and it is worth while to employ this treatment in every case possible. A recent case in our own series has shown this. This medical treatment, if it can stop the acute attacks, might be sufficient. In more advanced cases, however, if once the elephantiasis proper has developed, medical treatment is of importance only so far as it helps to prepare

the patient for operation and again post-operatively helps to prevent those very disastrous erysipeloid attacks. The sixteen cases which have been treated by Aubin[10] with streptococcus anti-serum have apparently shown some good immediate results. It is, however, a question as to the permanent results. Preventive treatment is important, namely, to prevent infections of the extremities such as ulcers and phlebitis, also to be careful in the removal of inguinal glands in hernia operations, and not to apply circular bandages in cases where there is danger of venous or lymph stasis.

The earliest reference to any surgical treatment other than amputation was made in 1851, when Carnochan and Morton in this country proposed the ligation of the main artery. This operation, besides risking gangrene, did not produce the desired results. In 1900, Mikulicz and others started to excise large cuneiform pieces of tissue from such limbs and they obtained occasional good results. Finally, Lanz, of Holland, starting with the idea that lymphatic stasis was the underlying evil, proposed a very radical operation for the establishment of new lymph-channels. He made an incision down to the bone, trephined the bone and placed strips of deep fascia into the trephine holes. Lanz obtained excellent results, but his operation was too radical. It is from this operation and from one which Handley proposed in 1908 that the Greek surgeon Kondoleon[11] adapted his operation. Handley proposed to establish new lymph drainage by placing silk threads in the subcutaneous tissues, starting at the wrist and extending up into the healthy tissues of the shoulder. The immediate results of his operation were very successful, but later investigations showed that the silk thread was represented by nothing more than fibrous strands and had ceased to give lymphatic drainage.

With Lanz's operation in view, Kondoleon, in 1912, proposed the following operation. Based on the very reasonable theory that in elephantiasis the superficial lymphatic system is diseased and blocked, while the deep lymphatic system is still sound and functioning, he proposed by the removal of the deep aponeurosis covering the muscles to open the way for the formation of new lymph channels between the deep and superficial lymphatic systems. His operation consists of an incision from the trochanter to the external malleolus, down to the deep fascia and the removal of a wide strip of this fascia. The same procedure is repeated on the inner side of the limb. The Kondoleon operation was first performed in this country by Matas in 1912 and he modified it slightly by excising considerable portions of skin and subcutaneous tissue and by sewing the deep fascia against the muscle in order to prevent the reformation of this fascia. Sistrunk[12] at The Mayo Clinic further modified the operation by removing much larger proportions of skin and subcutaneous tissue, thus trying to reëstablish the normal proportions of the limb. Payre,[13] in Germany, who claims to have originated his operation at about the same time as that by Kondoleon, employs an operation similar to that used by Sistrunk. Payre, who has done the same number of operations as Kondoleon, namely, twenty, stresses the pre-operative treat-

ment especially. He advises long-continued bed rest, often as long as four to five weeks, with bandaging and elevation of the limb in order to shrink it as much as possible. The smaller the leg at the time of operation the more tissue can be removed and the better the result. He also lays emphasis upon the fact that as much as possible of the skin should be removed in order to have a sufficient pressure of the skin upon the underlying tissues. Payre, and his co-worker, Kuntzen, take great care in preparing the skin of the affected limb, cleaning it every day and applying sterile bandages for almost a week preceding operation. Sistrunk and Auchincloss,[14] in New York, have independently advocated the correction of the deformity and the removal of as much as possible of the diseased tissues as one of the important features of a modified Kondoleon operation.

The actual technic of the operation consists of an elliptical incision of the skin, removing all excess skin; reflection of skin flap at least six centimetres laterally and then removing a large section of subcutaneous tissue and deep fascia; exposing the muscle and bringing it into direct contact with the skin.

If we now review critically the results of the surgical treatment, we find that the splendid improvement which the originators of this operation had hoped to obtain has not been fulfilled. Kondoleon, who reviewed his twenty cases, in 1924, stated that some of them were improved for as long as two years and then there was a recurrence of attacks. He states, however, that after the operation in spite of the attacks the limb or scrotum always returns to normal size again, and he believes this to be definite proof of the establishment of new lymph-channels by the operation. Summarizing his experience with the operation, he believes there is definite improvement after operation but not a "restitutio ad integrum." Again, Kuntzen, in reviewing twenty-two cases, shows that their immediate results were very good, but that the permanent results are not so encouraging. Out of sixteen cases of the lower extremity, two were completely cured; six were much improved, four very little improved and three were not improved at all. The cases showing the largest improvement were cases of secondary elephantiasis of long standing. The results of the radical operation for elephantiasis of the scrotum and penis have been better. Sistrunk, after ten years of experience, feels that the operation has definite value. Auchincloss, in Porto Rico, has had the same good immediate results, but he also has had many recurrences. The great factor in recurrence is the reappearance of the erysipeloid attack.

Case Reports.—Case I.—Mrs. M. L., aged fifty-three years, white. First admitted September 12, 1930, to Doctor Muller's service, Misericordia Hospital. Tremendous swelling of right leg. Eighteen years ago, when three months pregnant, the patient noted a generalized swelling of right foot and leg. This swelling would pit on pressure. The swelling persisted during the remainder of the pregnancy but did not become worse. Bed rest after parturition improved the leg, but getting up produced the same swelling. In spite of all palliative treatment, during the last eighteen years, the size of the leg became

gradually worse and in December, 1929, it attained its present proportions. (Fig. 1.) The patient was at that time unable to walk or even to perform her household duties on account of the size of the leg. It began to ulcerate and discharge as much as a quart daily of clear white lymph. The patient has never been farther south than Washington. She states that three months prior to her initial swelling she fell and injured her spine. At the time of her examination by us there was, however, no evidence of injury. Her previous medical history was negative. No elephantiasis in family, apparently only one abortive attack of erysipelas. Mother of four children. Physical examination entirely negative except for her right leg. The lower leg is most markedly elephantoid. The

FIG. 1.—(Case I.) Elephantiasis of right leg. Anterior view. Before operation.

FIG. 2.—(Case I.) Elephantiasis of right leg one and a half years after operation.

skin has become very much thickened, it does not pit on pressure, and in the ankle region is covered with numerous wart-like thickenings. The patient was prepared for a week and then the first-stage Kondoleon operation was performed. The skin, subcutaneous tissue, fat, deep fascia were removed from the trochanter to the external malleolus. From trochanter to knee a strip about two and one-half inches was removed and from the knee down the strip varied from two and one-half to five inches. A month later the second-stage Kondoleon on the inner side of the leg was performed. The healing of both scars progressed slowly but steadily and with the help of a small skin graft she was finally discharged eleven weeks after her first admission. The patient was admitted three times during the last one and one-half years for minor plastics on the same leg and at the present time her right leg has almost the same dimensions as her left one. (Fig. 2.)

She is again able to do her housework and can walk. She still has a small granulating area over her external malleolus, but this is healing steadily. For the patient's comfort it is also necessary that she still wears an elastic bandage on her right leg. She has never had any erysipeloid attacks during the last ten years.

CASE II.—W. S., boy, aged thirteen years. First admission, September 27, 1930, Doctor Muller's service, University Hospital. Recurrent painful swelling of both legs. Without previous disease or ill health the boy's legs became painful and swollen about a year before first admission. The condition lasted only for a few weeks in the right leg, but remained for about two months in the left leg. The painful swelling with redness

FIG. 3.—(Case II.) Elephantiasis nostra of left leg before operation.

FIG. 4.—Four months after operation.

and fever returned about every three to four months in the left leg. In the interim, with otherwise good health, the left leg remained, however, somewhat swollen but was not as large as during acute attacks. On September 25, the patient had another attack, which began with chills and fever and was followed about eight hours later by redness and swelling and severe pain. This pain and redness started at the internal malleolus and ascended up the leg as high as the iliac crest. There were no history of trauma and no hereditary factor present. Patient had scarlet fever in June, 1928. Tonsils had been removed several years previous. Physical examination was negative except that the left foot and leg were swollen considerably. The skin of the foot and ankle was thick, dry, coarse and scaling with a tendency to eczema and ulceration. The foot and leg were not tender. A diagnosis of elephantiasis nostra due to repeated attacks of lymphangiitis was made. Pre-operative treatment was started and with the leg elevated the swelling

decreased considerably. The picture shown (Fig. 3) was not taken till two weeks after admission. Kondoleon operation October 16, 1930. The tissues of the lower leg had a decidedly bony feel. The boy's wound healed perfectly and he was discharged November 10. In December, 1930, the patient returned for the second-stage Kondoleon operation. (Fig. 4.) The swelling at this time was much less. Seen in follow-up clinic April, 1931, there was still slight swelling over the external malleolus of left leg. He was going to school, was still wearing an ace bandage. Had not had any attacks since operation. On June 11, 1931, he woke up with a sudden pain in the right foot, followed by a chill and swelling of his right foot this time. The red area spread up the knee in four days. He was admitted with a temperature of 103° and he was treated and diagnosed as erysipelas by the receiving ward intern who did not know his previous history. The left leg at this time was perfect. About the right knee there was an area of redness simulating erysipelas and the entire leg was very much swollen. Ultra-violet light was

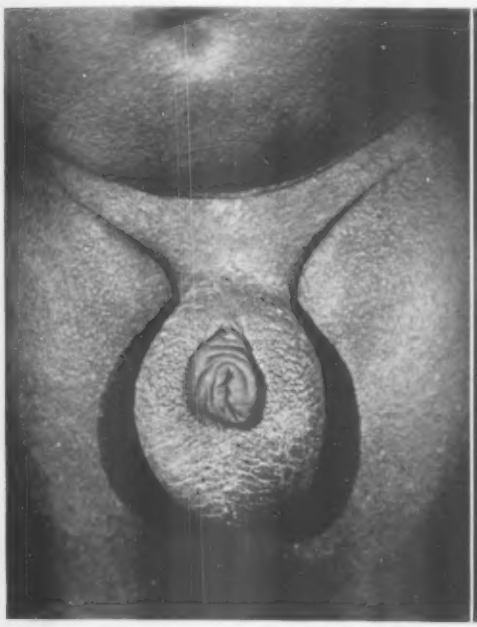

FIG. 5.—(Case III.) Elephantiasis of scrotum before operation.

FIG. 6.—Elephantiasis of scrotum nine months after operation.

applied and arcase dressings. The temperature dropped the next day and the leg became progressively smaller, the redness disappeared, but the inguinal lymph-nodes remained large and tender, and he developed subsequently an abscess in his inguinal region which was incised and drained. A non-hemolytic *Staphylococcus aureus* was recovered and a vaccine was prepared. The patient was discharged again and vaccine treatment was started. His right leg has been free of attacks of swelling since then. He was seen at the follow-up clinic March 10, 1932, and he reported another acute attack of swelling and redness in his left leg, which, however, subsided in twenty-four hours. Both ankles at this time were still somewhat swollen but his legs had never reached the previous elephantoid proportions. He is still wearing an ace bandage, and he is still receiving vaccine treatment. In his case the erysipeloid attacks might prevent a permanently good result.

CASE III.—Man, colored, aged fifty-one years. First admitted May 20, 1931, to Doctor Muller's service, University Hospital. For five years the patient has been treated for lichenplanus in his inguinal and perineal region. During this time there was

a gradual swelling of his scrotum. He also had a strongly positive Wassermann. He was diagnosed as elephantiasis nostra by the dermatology department. Physical examination revealed a scrotum the size of a man's head (Fig. 5) with the penis entirely buried in the scrotum. Operation May 21, 1931, lateral elliptical incisions, removal of almost the entire scrotum. The testicles were replaced in a small pocket of skin. Convalescence normal. Culture showed a none-hemolytic staphylococcus and diphtheroids. Patient was seen in follow-up April, 1932, and his scrotum was small, while the penis was of normal proportions. (Fig. 6.) He had not had any attacks of painful swelling and he was again able to have intercourse, which had been absolutely impossible before operation.

Case IV.—Male, white, aged forty-eight years. First admitted November, 1930, to Doctor Muller's service, University Hospital. He was sent in as an inguinal hernia. Four years before admission he was operated upon for bilateral inguinal hernia. Three months later the patient noted the swelling in the left side of the scrotum reappearing. Physical examination showed poor teeth and tonsils; there was considerable suprapubic swelling and the scrotum was as large as a cocoanut. The skin over the scrotum is reddened, thick, scaly and boggy; the left side of the scrotum was larger than the right side. The penis is very swollen. Because of recent flare-up of redness and swelling, the operation was postponed. The diagnosis was elephantiasis nostra, probably following his bilateral hernia operation. The patient gave a definite history of fever and vomiting associated with the scrotal swelling. February 19, 1931, operation was performed, consisting of excision of scrotum, bilateral bottle operation for hydrocele and a plastic on the penis. The hydrocele operation was not performed for hydrocele but to prevent the later formation of hydrocele. Lateral incisions were made from the antero-lateral portion of the scrotum down to the postero-lateral portion, the direction of the incision being governed by the extent of diseased tissues. Lateral flaps of normal skin were then secured and the entire scrotum was excised; the testicles themselves were freed and completely isolated; the tunica vaginalis of each testis was opened and inverted to prevent formation of a traumatic hydrocele. A diamond-shaped piece of skin and subcutaneous tissue was then removed from the posterior part of the penis. The lateral flaps of normal skin were then shaped into the new scrotum. The recovery from operation was uneventful. A culture from the scrotum showed hemolytic staphylococcus albus of auranticus type and a none-hemolytic *Streptococcus ignavus*. These are both rare organisms, and are of great interest. The pathological section showed marked œdema of the scrotum and penile tissues with localized areas of round-cell infiltration. The patient was seen in follow-up clinic March 10, 1932. His scrotum is much smaller. He still has occasional attacks of fever, chills, swelling and redness of the scrotum, but the swelling always returns to its normal size very soon and the attacks are much shorter.

Case V.—Male, white, aged forty-seven years. Admitted November 3, 1931, to Doctor Muller's service, University Hospital, with a fracture of the right femur, lacerations of the forehead, right knee and left ankle, after being struck by a truck. He also had a possible skull fracture and an intra-abdominal or retroperitoneal hæmorrhage. He was put into the Russel traction apparatus and after a fair reduction of his fracture no further attempts were made on account of his serious condition. During the first two weeks he was very sick and several times it seemed necessary to open his abdomen. He was in apparent good health again one month after the accident, but at this time X-ray revealed non-union of his fracture. Open reduction with plating was undertaken December 8, 1931, and a body plaster case was applied. Immediately after the open reduction there was only a slight flare-up of temperature and some abdominal distension. On December 18, 1931, he developed a fever of 104°, his left leg, the right leg was fractured, became red and swollen, he was very sick with chills and vomiting. The entire case was removed and the patient was placed in the Russell's apparatus again. There was a temporary improvement following the removal of his case and then his temperature began to mount again and his leucocytes rose to 26,000. On December 27, 1931, there began

œdema and redness of right leg at the ankle and slowly involving the entire leg up to the iliac crest. One area over the right thigh appeared almost fluctuant and was incised but only clear white lymph was obtained. X-rays at this time showed possible osteomyelitis; this, however, was proved to be wrong in subsequent films. There were several areas of redness, erysipelas-like, with very brawny induration developing around both his ankles, over his right thigh and just below the left iliac crest. During early January, or two months after the accident, there was also the development of scrotal œdema. The entire picture appeared at this time as of an acute attack of elephantiasis nostra of both legs and scrotum. Both legs and the scrotum became tremendously enlarged. On January 10, 1932, active treatment for acute elephantiasis nostra was started. He received repeated small blood transfusions and repeated injections of twenty-five cubic centimetres of polyvalent anti-streptococcus serum. Ultra-violet therapy was also started and viosterol by mouth. After six injections of anti-streptococcus serum, the œdema of his legs began to subside gradually. During the last two months he has improved steadily but slowly. His fracture seems well united and he is out of bed; of course he is not yet able to walk. There remains only one area of brawny induration over the lower right femur. He has not had any more attacks of fever and swelling. The sinus over the right thigh has stopped draining large quantities of lymph. Cultures taken from tissue did not show growth, but cultures taken from the sinus in his leg showed a hemolytic *Staphylococcus albus* and *Bacillus pyoceaneus*. Of course, the great question in this case, as it is in all other cases of elephantiasis, is, will the patient continue to have erysipeloid attacks; and if the attacks will recur he surely will develop true elephantiasis.

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INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR

A CLOSED DOUBLE-SCREW METHOD FOR REDUCTION AND FIXATION—PRELIMINARY REPORT

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In reporting any method of treatment, the surgeons to whom it is presented, accept or reject it in accordance with the counseling of their past experience. The method about to be reported has but lately emerged from the rigorous tests of the anatomical laboratory. Because it has excited such lively and complimentary interest among men interested in the treatment of fractures, I take the liberty of making a preliminary report.

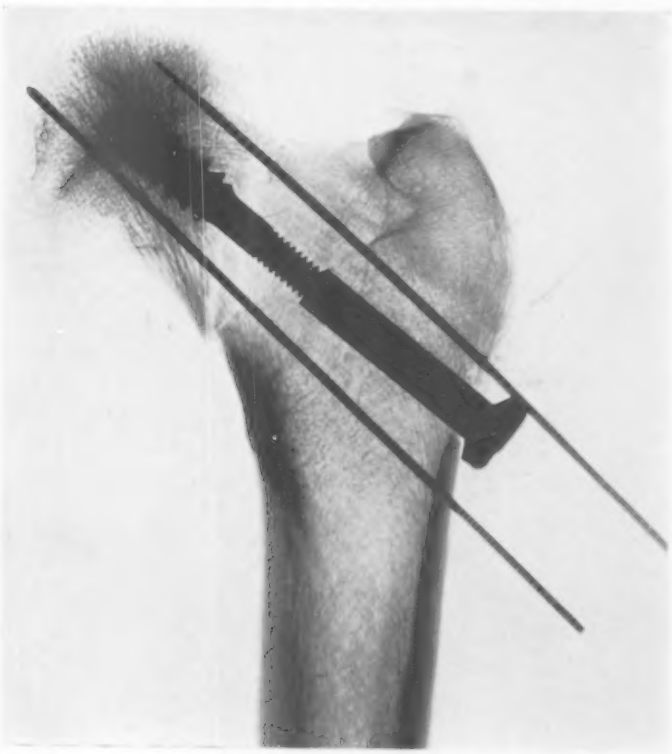

Fig. 1.—Model illustrating both the guide wires and double-screw.

Briefly, the procedure is that, under röntgenographical control, the neck and fractured head are placed in line through the use of the Whitman position. The fragments are fixed by two Kirschner wires which also act as directional guides. At this point, the simile is apt that the head is strung on the wires like a bead. A double screw of special design is inserted.

It does not fall within the scope of this paper to discuss the results in

the treatment of intracapsular fractures of the neck of the femur. That has been done recently in an excellent article by Gill.[1] His conclusions are notable for their frankness, and will convince anyone that there is great room for improvement.

The excellence of the results recently reported by Smith-Petersen[2]

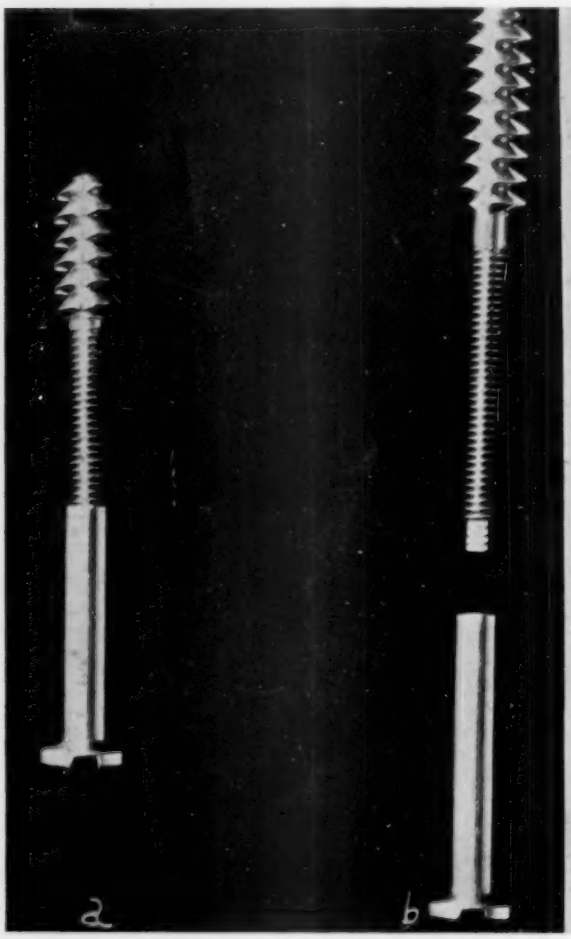

FIG. 2.

FIG. 3.

FIG. 2.—(a) Double-screw assembled. (b) (Above) Double-screw detached, showing in proximal portion, burr, shaft with square end for socket wrench. (b) (Below) The traction-cap and groove for screw-driver.

FIG. 3.—End-view of burr and traction-cap showing control hole.

through the use of the three-flanged nail has revived interest in the use of mechanical internal fixation in such fractures.

Experience with the method will determine whether such fixation will be used in fresh fractures, or when non-union has occurred. In my opinion, its field will be greatly broadened to include the numerous doubtful surgical risks having this type of fracture, if fixation can be performed without open-

ing the hip-joint. This work was undertaken somewhat less than a year ago to determine if such a method could be devised.

At the outset it was determined that the mechanical device used for fixation of the fragments must meet certain requirements. These were, first, ease and accuracy of introduction; second, secure fixation; third, small size; fourth, adjustable length to meet variations in femora; fifth, ease in removal. We believe we have met these in the appliance about to be described.

An entirely new type of screw was designed. Rustless iron* was the

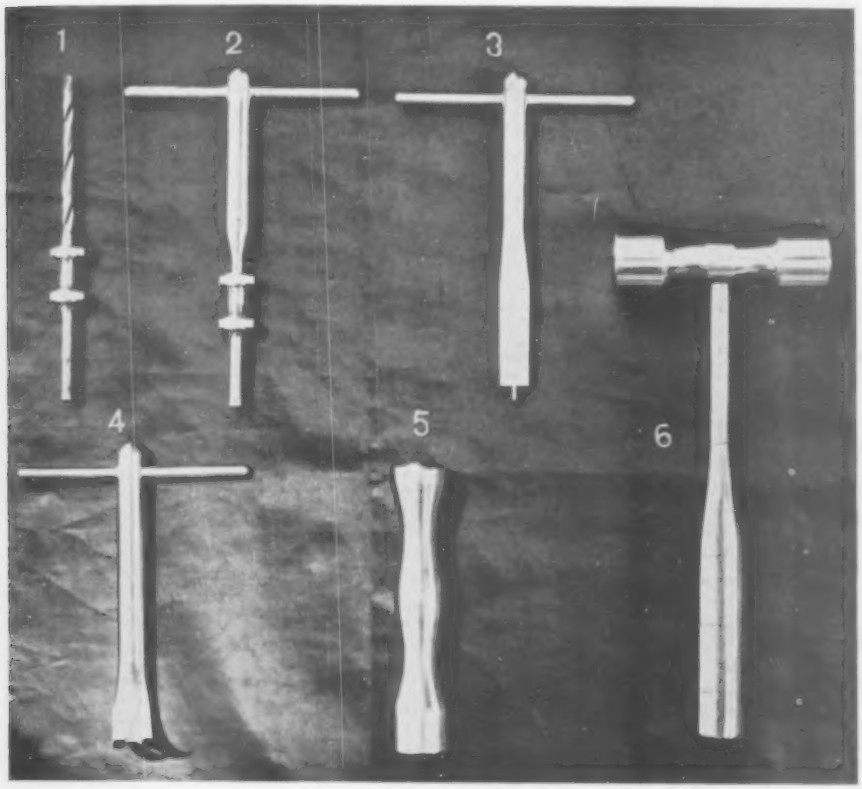

FIG. 4.—Armamentarium showing: (1) Drill with adjustable stop on shaft. (2) Socket-wrench for squared end of proximal part of screw. Adjustable stop on shaft. (3) Screw-driver showing projecting tip for central hole of traction-cap. (4) Extractor to be used in case of false passage. (5) Impactor. (6) Hammer.

material chosen. It can be accurately machined, highly polished, and it has been shown by Zierold[3] and Henry[4] to be less irritating in bone than other

* Free machining Stainless Iron No. 2—

	Per cent.		Per cent.
Carbon	.10 maximum	Phosphorus	.03 maximum
Manganese	.30-60	Sulphur	.30-45
Silicon	.30-50	Molybdenum	.55 approx.
	Chromium	14.00-15.50	

Reported by Research Laboratory Crucible Steel Company of America.

materials. Only the briefest attempt will be made to describe the screw and the instruments used as the illustrations will do this far better.

The screw consists of two parts, a proximal one for the femoral head, and a distal one, or traction-cap for the trochanter. The proximal portion has likewise two parts, a head and a shaft. The head is burr-shaped, is regularly threaded, and has four deep grooves cut at a right angle to the threads. It was found that this type of head cut easily through bone, making its own receiving grooves in the process. The shaft is threaded to fit the receiving shaft of the traction-cap, and the end is squared for the use of a socket wrench.

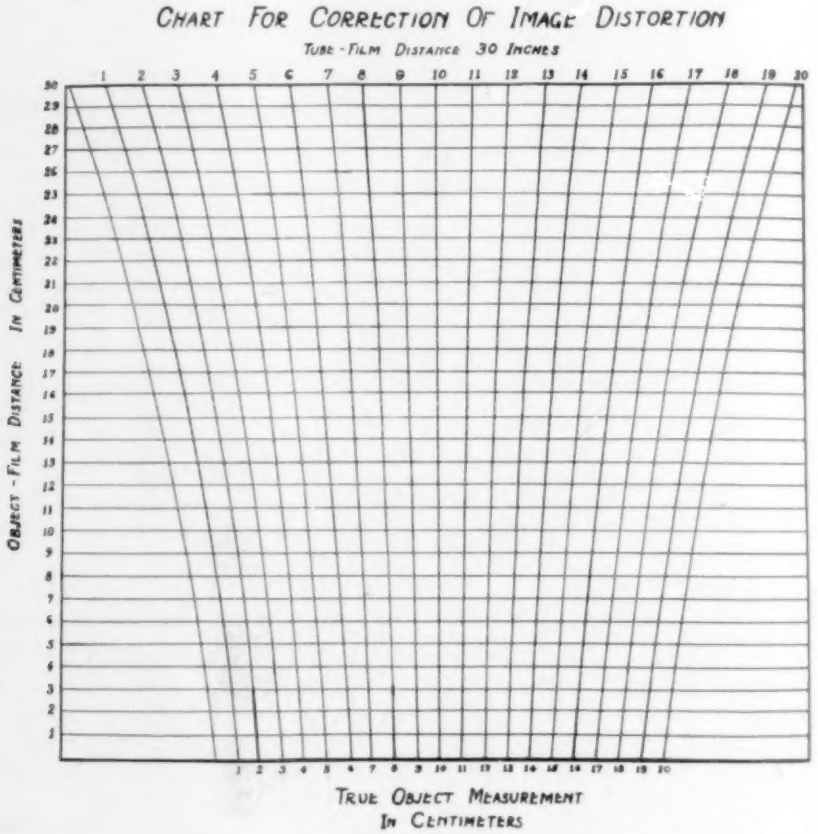

FIG. 5.—This chart actually measures 31 centimetres along the ordinate and 33.5 centimetres along the abscissa. (After Henry J. Walton, M.D., American Jour. of Roent. and Radium Therapy, vol. xv, No. 6, p. 758, June, 1931.)

The distal portion of the appliance, or traction-cap, has a shaft and a head. The head is rounded and the face grooved for the use of a screw-driver. In the centre of this groove is a hole designed to fit a projecting tip on the screw-driver. This obviates slipping, but in addition has a more important purpose. The double-screw functions by action at two points, one where the fractured femoral head is fixed on the burr, the other at the point where pressure is directed against the cortical bone of the trochanter by the traction-cap. It is obvious that a screw that is too long could be completely closed before the fragments were locked. In screwing on the traction-cap, the pin on the end of the screw-driver will strike the shaft of the proximal portion of the screw before complete closure can be effected. This would give notice to the operator to

substitute a proximal part with a shorter shaft. The proximal portion has been made with shafts of two lengths, one cap fitting both. In the disarticulated and fractured femoral head, and in cadaver experiments, an exceedingly firm union was established.

Armamentarium.—The drill and socket wrench, both with adjustable stops, the screw-driver extractor, impactor, and hammer seem to need no explanation other than the illustration. A Kirschner wire drill and a motor-driven device used for the large drill form a part of the equipment used. The motor is not essential as we have used an ordinary carpenter's wood-drill.

Technic.—In any closed method, measurement and localization must be by means of the röntgenogram. An interesting suggestion was made by Dr. Rex Diveley that the fluoroscope be used. It is quite sound but my personal feeling is that fluoroscopical technic would entail prolonged exposure for the surgeon.

In detail, the actual steps are as follows: A preliminary anteroposterior röntgenogram is made, the tube target centred over the femoral head and neck, and elevated to a point exactly thirty inches from the plate. The distance from the anterior margin of the trochanter to the plate is then measured and recorded in centimetres. The patient is placed in the Whitman position during the exposure. Measures are made on the film to allow Kirschner wires to pass from the trochanter through the neck and head. The desired screw-depth is likewise measured on the film.

The measurements in the case to be reported actually made on the film are as follows (see Fig. 9):

(*a*) Superior for upper Kirschner wire = 11.6 centimeters
(*b*) Inferior for lower Kirschner wire = 12.8 centimeters
(*c*) Middle for double-screw = 9.0 centimeters

These measurements are corrected for magnification by consulting the chart. The object film distance, *i.e.*, the measurement from the trochanteric region to the plate, is thirteen centimetres. The measurements given above are then applied along the line reading thirteen centimetres and the correct figure obtained without intermediate calculation. For example, it will be observed that the measurements for the superior Kirchner wire (*a*) which is 11.6 centimetres, when laid on the transverse line 13, fell at a point between vertical lines 9 and 10 to give a measurement of 9.7 centimetres. Hence, the measurements to be used, having now been corrected for Röntgen magnification, are as follows: (*a*) 9.7 centimetres; (*b*) 10.7 centimetres; (*c*) 7.5 centimetres.

Pre-operative plaster bandages should be applied from the foot to a point six inches above the knee-joint on both legs. This helps in maintaining position as it eliminates turning at the ankle. Extension straps are placed over these and the patient placed in the Whitman position; *viz.*, legs extended in a position of wide abduction and extreme internal rotation.

The anæsthetic of choice is given, and I believe local anæsthesia will prove quite satisfactory. In the reported case, nitrous oxide-oxygen was used. A

two-inch trochanteric incision is made, using the gluteal ridge as a guide, and starting one inch below this point and one-half inch from the anterior

FIG. 6.—Curved cassette for lateral röntgenograms of femoral head and neck.

margin of the femur. The first wire, of a length determined by the measurements, is drilled in direct transverse plane, and one inch below a second wire of correct length is similarly drilled. The part of the wire that was gripped

FIG. 7.—Anteroposterior view immediately following injury.

FIG. 8.—Anteroposterior view ten weeks after injury.

by the chock of the drill projects from the bone. At this point anteroposterior and lateral röntgenograms are made, and if the wires are satisfactorily placed in both views the next step is ready. If one or both are not so placed, other

wires are used, the first pair giving the proper location for the second, the first then being withdrawn. For the purpose of prompt identification in the

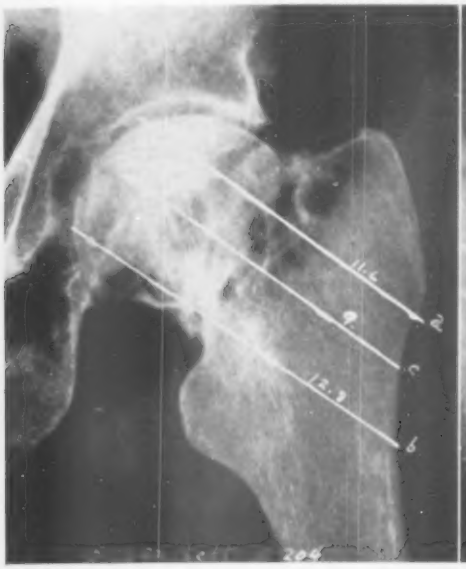

FIG. 9.

FIG. 10.

FIG. 9.—Anteroposterior view four months after injury showing neck erosion and non-union. Measurements made on this film.
FIG. 10.—Anteroposterior view showing both wires apparently perfectly placed.

lateral view, it might be well to identify one wire with a numeral on the projecting end.

A stumbling block was encountered in the development of a satisfactory

FIG. 11.

FIG. 12.

FIG. 11.—Lateral view showing upper wire in good position, lower wire posterior to neck.
FIG. 12.—Lateral view showing position of double-screw.

technic for the taking of lateral röntgenograms with the patient on the pelvic support of the fracture table. A curved cassette was constructed which could be slipped between the upright bar and the patient's groin. Further

FIG. 14.—Anteroposterior view immediately following removal of double screw.

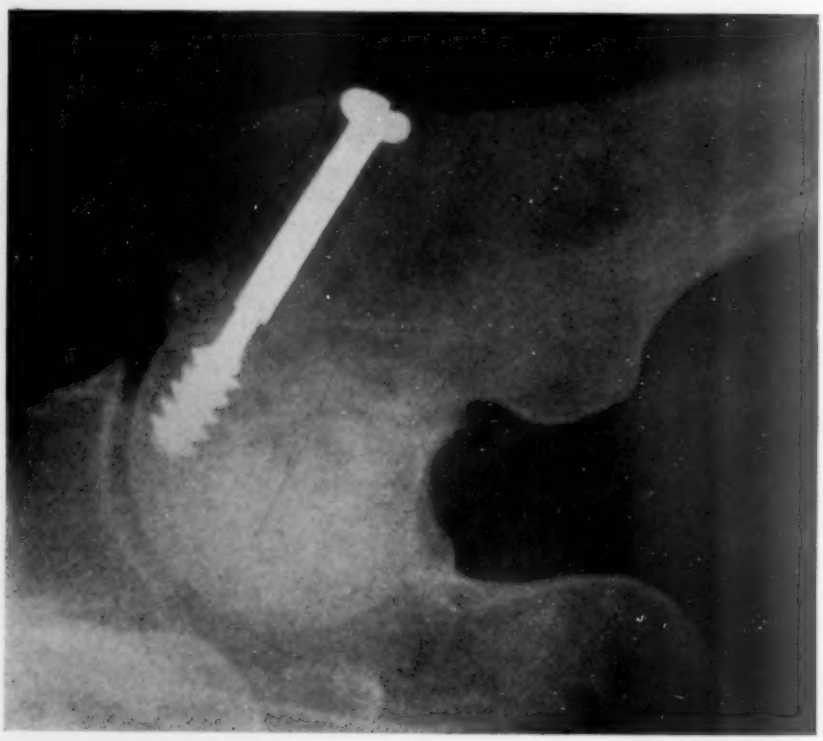

FIG. 13.—Anteroposterior view showing position of double-screw.

difficulty arose in lifting the patient on and off the cassettes. This difficulty, though not serious, is time-consuming. It will be overcome by cassette-holders or frames, which will enable the cassettes to be removed or inserted without moving the patient, once in position.

Once the wires are in the proper position, a stop is placed on the shaft of the drill at the measured distance, and a drill-hole slightly smaller than the screw-head is made. The projecting ends of the wires act as a guide for the drilling direction.

In the cadaver, it was found that the wires eliminated any tendency for rotation of the head, during the subsequent steps. The proximal portion of the screw is then placed in the socket-wrench, and a stop placed on the shaft of the wrench at the previously measured drill depth; *viz.*, pin length plus a measured distance on the shaft of the socket-wrench equals the drill-length. The head is firmly engaged on the burr by simply turning the handle of the wrench. The distal portion of the double-screw or traction-cap is threaded on the shaft of the proximal part and tightened with the screw-driver. When it has been tightened to the limit, the impactor is placed over it and given several sharp blows with the hammer. Several additional turns can usually be made. The guide wires are removed and the skin incision closed.

Case Report—P. M., male, aged sixty-five, January 20, 1932, slipped on an oily floor, fracturing the neck of the femur close to the hip-joint. The typical Whitman treatment was given for ten weeks. The röntgenogram made at that time reported that the fragments were in good position and united by hard callus. He was given a splint designed to prevent weight-bearing, a heel-raise on the opposite side, and crutches. Pain was complained of at intervals, and another röntgenogram taken six weeks later showed marked erosion of the neck of the femur.

Non-union having persisted for almost five months on May 31, 1932, the procedure as previously described was performed. The pre-operative measurements were as given in the example; upper wire 9.7 centimetres, lower wire 10.7 centimetres, screw-measurement 7.5 centimetres. It is worthy of note that in this first clinical attempt the screw was placed directly in the centre of the head in the optimum position. A study of Fig. 13 will show the drill track below the screw. It was found that the burr did not grip in this position, and I believe study of the röntgenogram indicates central necrosis of the head. Another drill-hole was made slightly higher, explaining the final position of the screw. At that point satisfactory fixation and impaction were effected. The necessity for the lateral röntgenogram is shown by a study of Figs. 10 and 11, which show excellent position for both wires in the anteroposterior view, but the lower wire slightly posterior to the neck in the lateral view. The upper wire, however, was in excellent position in both views, and the projecting end gave the proper localization for the subsequent steps.

Convalescence was entirely uneventful. No plaster case was applied but instead a light pelvic brace, partially immobilizing both legs to above the knee-joint, in slight abduction. Baking and massage were started immediately and movements below the knee encouraged.

Röntgenograms were made at monthly intervals. At the end of four months, union was considered satisfactory. Generalized bone atrophy was noted in the segment occupied by the screw. On October 14, 1932, under local anesthesia, it was removed. The burr of the proximal portion was still tightly engaged in the head. Six months after fixation, the range of motion in the affected hip is roughly one-half normal, motion is painless and weight bearing, while still protected, is well tolerated.

Comment.—Necessarily, a preliminary report is the place for strictly limited conclusions. A method has been devised whereby intracapsular fractures of the neck of the femur can be internally and mechanically reduced and fixed using a closed technic. The detailed results of this method of treatment will be made the subject of a subsequent report.

I wish to make grateful recognition of the untiring assistance rendered me by Dr. David S. Dann and Mr. Erich Hanicke. Many of the features of the various appliances are entirely the product of Mr. Hanicke's ingenuity. The röntgenographical technic was similarly developed by Doctor Dann.

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LOCALIZED TUBERCULOSIS OF THE CHEST-WALL *

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Graham[1] states that "tuberculosis is the most common condition involving the ribs and sternum," and Riedinger and Kümmell[2] found 104 cases of tuberculosis of the ribs and sternum among 1,795 cases of bone tuberculosis in the Eppendorf Hospitals. Recently there appeared a report from the Maritime Hospital of Berck, France, recording forty-five cases of cold abscess of the chest-wall during a five-year period.[3] John Alexander,[4] with his extensive practice among tuberculous patients, reports that he saw seven cases last year. In striking contrast to these figures are those from the surgical services of two large hospitals in this country. At the Episcopal Hospital in Philadelphia the records of only three proven cases of tuberculosis of the chest-wall could be found for a twenty-one-year period; while at the Hospital of the University of Pennsylvania during the same period no proven cases could be found in the surgical records, although in each institution a number of cases of bone tuberculosis are seen each year. This striking discrepancy in figures can be explained in only one way. Tuberculosis of the chest-wall is usually neither very painful nor dangerous to life, and as most physicians consider its treatment purely palliative at best they do not send their patients to the surgeon. In certain centres the practitioners have learned of the good results of proper surgical therapy and so refer their patients. Here in Philadelphia it seems that such is not the case.

That the subject has not been ignored in recent literature is attested by the excellent article by Heuer[5] in Nelson's System of Surgery, and the careful reports of Richard,[6] Ito,[7] Sorrell,[3] Kaufmann,[8, 9] and others.

The term, localized tuberculosis of the chest-wall, is here applied to those lesions in which there is no demonstrable communication with a tuberculous process in the spine, or intrathoracic tissues. Though this would suggest that the local process was a primary one, such is rarely the case for a careful search will usually reveal evidence of tuberculosis elsewhere in the body. The lesion of the thoracic cage is thus only a local manifestation of a systemic disease.

Pathogenesis.—Conflicting theories have been advanced to explain the development of the local lesion. The older and more generally accepted view considers the blood-stream as the distributing medium with a costal periostitis, or osteomyelitis, as the first indication of the localization. Less frequently a soft tissue abscess forms first and rarer still the costal cartilage shows the initial change. Notable among the writers who have emphasized

* Read before the Philadelphia Academy of Surgery, April 4, 1932.

this method of origin are Heuer,[5] Ricard,[10] and Sorrell.[3] The concept of the development of the chest-wall process as the result of lymphatic spread from an intrathoracic focus has been ably supported by the writings of Auchincloss[11] and Kaufmann.[8, 9] They believe that the structures beneath the chest-wall act as the distributing foci. Even though no evidence may be apparent at operation Auchincloss feels that the lungs, pleura and mediastinal lymphatics are "preëminently responsible." Kaufmann,[8] in a recent article, gives the results of his study of specimens removed at operation. He found that the lymph-nodes of the intercostal spaces were always involved. These were infected, he believes, as the result of a tuberculous pleurisy but did not give rise to an abscess until the pleural lesion had become healed. This assumption would account for the healthy appearance of the pleura so frequently observed at operation on these cases. Depending upon the contiguous structures encountered in the outward spread of the process the apparent lesion would be an osteitis, chondritis, or soft tissue abscess. John Alexander[4] also believes that most cases spring from infection of the thoracic lymphatics, especially those of the internal mammary chain.

From a study of the literature and from my own experience it would seem that there is abundant evidence that the tuberculous process of the chest-wall may arise either by way of lymphatic extension from an intrathoracic focus, or by way of the blood-stream from a similar area. The concept of a true primary lesion rests on the knowledge that no tissue of the body is immune to invasion by tubercle bacilli. On the other hand, practically all patients with the local manifestation show evidence of concurrently active, or previously active, intrathoracic tuberculosis. This I believe to be true in spite of the reports of Mercadé,[12] Gruget,[13] and others to the contrary. For in none of their cases was Röntgen examination of the chest recorded. And it is only by such investigation that the intrathoracic tissue can be said to be free from tuberculosis.

For convenience of discussion the process will be considered in regard to the various locations in which it develops. The osseous ribs and sternum are most frequently attacked, the soft parts less frequently, and the costal cartilage least of all. In the report from the Berck Maritime Hospital for the years 1922 to 1927, there were thirty-one cases of tuberculosis of the ribs, ten of the soft parts alone and only four of the costal cartilages, and the reporters consider the cartilaginous origin to be rarer than these figures would indicate.

The Soft Tissues of the Chest-wall.—Although the soft tissues of the chest-wall are less frequently the site of early involvement than the bony cage, they are almost invariably involved by the time that the patient presents himself for treatment, regardless of the site of the origin. The most obvious type of soft tissue abscess arises as a result of aspiration of a tuberculous pleural effusion and is an example of local implantation of organisms. Heuer[5] has reported a case of multiple tuberculous abscesses occurring in the subcutaneous tissue of a man's chest, and one may see a superficial abscess

arising from an axillary, or pectoral lymph-node. The common type, according to Sorrel and Sayag-Dromer,[3] arises in the subcutaneous tissue, or in the connective tissue in the muscles. The pleura, the endothoracic fascia, and the lymphatics of the chest-wall, have all been described as sites of origin. Whether or not it starts in the pleura or other deep-seated layer the process always advances outward, either directly, or after a lateral deviation. Practically all writers agree that inward spread is unknown. During the deep stage no symptoms may be present, or there may be a dull constant pain which is accentuated by deep breathing. As the lesion becomes more superficial a slight swelling is noticed which grows so slowly that it causes little alarm. At this time examination reveals a rather firm, rounded protuberance which gives the impression of deep fluctuation. There is usually no acute tenderness but pressure may produce vague discomfort. Later the skin shows the effects of pressure, becoming thin and cyanotic, and a definite encircling zone of induration can be felt. Eventually, in the untreated case the skin is perforated, allowing the escape of fluid which varies in character from a thin, clear, yellow one to a thick, grayish one. The important feature of the fluid is its sterility on routine culture and the positive evidence of tuberculosis elicited by guinea-pig inoculation or growth of the bacilli on special media. Following the perforation a sinus persists for a long time before secondary infection develops and produces the characteristics of an acute pyogenic abscess.

In arriving at a diagnosis of the condition the history of insidious development of the swelling is important, as is the absence of the usual signs of acute inflammation. Evidence of tuberculosis elsewhere in the body is very helpful and röntgenographical study of the chest should not be omitted. Aspiration of the unruptured abscess usually clinches the diagnosis, although rarely histological study of the tissue is necessary. The manner of removal of the fluid is very important. Aseptic technic is essential, and the needle should be introduced through the adjacent normal skin in order to avoid injury to the thin roof of the abscess which would result in sinus formation and secondary infection.

As must be repeatedly emphasized, the abscess is only the local manifestation of a systemic disease and its treatment, therefore, must be undertaken only in conjunction with measures directed at the underlying process. Under very favorable environmental conditions combining heliotherapy with rest, fresh air, and nourishing food, the chest-wall lesion may undergo spontaneous healing. This, unfortunately, is of rare occurrence. It is more practicable to also institute local treatment. In the past this has consisted in keeping the abscess empty by repeated aspiration, or by replacing the contents with iodoform and glycerine. Incision and evacuation of the abscess with primary closure is little better as it does not remove the source of the trouble. Far more rational seems the complete extirpation of the diseased tissues with primary air-tight closure of the wound. When this is done one can definitely exclude the presence of an underlying osseous, or cartilaginous involvement,

or satisfactorily deal with it if present. The results from this method are excellent and the patient is spared a long-standing lesion.

The Ribs and Sternum.—Tuberculosis of the ribs and sternum is more common than that of the cartilage or soft tissue, as has been noted above. In discussing the pathogenesis of the chest-wall lesions it was pointed out that there was considerable evidence to support the theory that the underlying focus was beneath the rigid thoracic cage and that the ribs and sternum were involved in the outward extension of the infection. According to Heuer,[5] on the other hand, the process in the rib usually starts centrally as if it was hematogenous. He states that there is at first a small focus of tuberculosis in the medulla of the bone. This gradually increases in size, causing destruction of the cancellous bone and a bone abscess results. The periosteum becomes thickened as does the overlying fascia and these together with the cortex are perforated by the expanding process and a soft tissue abscess is produced. Further progress may follow two main lines; one outward and the other laterally. If advance is directly outwards the overlying skin is soon involved and a sinus forms. If the disease progresses laterally the cartilage becomes involved. In some cases many ribs are attacked and the resultant abscess is a large one. In either case the skin is eventually damaged and following the appearance of sinuses secondary infection develops.

An interesting example of the outward spread of the disease was a case reported by V. Aloi,[14] in which the breast of a pregnant woman became the site of a large abscess arising from a tuberculous osteomyelitis of the underlying sixth rib. Less frequently, the process begins as a periostitis. According to Sorrel and Sayag-Dromer,[3] after destruction of the periosteum ulceration and erosion of the bone take place with the formation of a cavity containing small sequestra. Pathological fracture may occur but usually there is simply the outward extension of the process with the formation of a soft tissue abscess. Heuer[5] points out the importance of the site of the initial periosteal involvement. The anterior surface is most frequently involved. When the posterior periosteum is the point of origin the line of advance is usually through the overlying rib. Cases have been observed in which extension occurs between the chest-wall and the costal pleura. The destruction of the posterior periosteum causes necrosis of the rib but sequestra are rarely observed. It is quite generally agreed that inward extension of the process to involve the pleura is never observed.

The ribs most frequently involved, according to Sorrel and Sayag-Dromer,[3] are the fourth to the tenth; and of these the lateral and posterior segments are sites of choice.

The sternum is attacked in the same way as the ribs and the changes occurring in it are similar. Not only may the bone itself be the site of the disease but the joints also may become involved. Perforation posteriorly from the sternum is usually prevented by the firm layer of fascia which separates it from the mediastinum, but a few cases have been reported in

which this has occurred. Such a complication is of course of grave significance.

In considering the diagnosis of tuberculosis of the ribs and sternum the same points stressed under the heading of soft tissue tuberculosis are to be considered here. In addition, however, the bone changes will be revealed in most instances by the röntgenogram. Indeed, at times a diagnosis of tuberculosis of the rib or of the sternum may be made before the involvement of the overlying soft tissue takes place when the röntgenogram incidentally demonstrates the lesion during the Röntgen study of the lungs of a patient with tuberculosis. In considering the diagnosis of tuberculosis of the sternum one must always carefully consider the possibility of syphilis as gummata of the upper sternocostal region are not infrequently found. The laboratory here proves of great assistance with serological studies.

Treatment.—As has been stated before, general treatment must always be followed and attention is not to be limited to the obvious local lesion. Under exceptionally favorable conditions conservative treatment may suffice in the early stages. In general, however, surgical intervention is necessary. This will consist of excision of the soft tissue abscess and of the underlying involved rib or sternum. It is important to make a wide excision of tissue going well out into the healthy area. It is not usually necessary to remove the entire periosteum with the rib, as in most cases only the overlying portion is involved, and that secondarily. And it is striking how many cases do well after simple subperiosteal resection of the diseased bone, when one considers that according to some writers the bone is only secondarily involved. In those cases in which secondary infection has not developed, even in the presence of sinuses, primary closure of the wound without drainage is the method of choice. Practically all recent writers are firmly in agreement on this point. If it is necessary to use a drain because of uncontrolled oozing, the material should be of non-irritating substance and should be removed after one or two days at the latest. Meticulous hemostasis and the obliteration of large dead spaces by pressure of firm dressings, by suture, or muscle pedicle graft will do much to ensure primary healing.

The Costal Cartilages.—Tuberculosis of the costal cartilage occurs quite frequently as the result of extension of the disease from the corresponding rib, and less frequently from disease of the adjacent lymphatics. About these two forms there is little dispute. On the other hand, the question of primary tuberculous chondritis has brought forth much discussion, especially in France. Two forms of the disease have been recognized, that starting in the perichondrium and that in the cartilage itself. Because of the admittedly abundant vascularity of the perichondrium very little doubt has been expressed about the existence of tuberculous perichondritis. But this unanimity of opinion has been lacking when there has been discussion of tuberculosis of the central portion of the cartilage. The chief obstacle to belief has been the apparently widespread opinion that costal cartilage is avascular. It was with this idea that the reports of Mercadé,[12] Gruget[13] and Dujarier,[15, 16]

were attacked. And this in spite of the work of Linberg[17] showing penetration of the cartilage with blood-vessels after the tenth year. More recently the studies of Nikolajew,[18] and of Leblanc and Sayag[19] have given adequate anatomical foundation for central hematogenous infection of the cartilage. Of the later reports of cases of tuberculous chondritis that of Benedetti-Valentini[20] is the most convincing. In his paper excellent photomicrographs of tubercles in the central portion of the cartilage are reproduced.

Whether or not the process is truly a primary one is mainly an academic question for the clinical course is quite constant. Two forms of onset are recognized, one starting in the perichondrium and the other starting in the cartilage proper. In the former there is at first a thickening of the perichondrium with the formation of tuberculous granulation tissue and pus, after which destruction of the cartilage ensues. Associated with this is the development of a soft-tissue swelling and the typical cold abscess appears. The process may remain localized with the formation of a sinus but the tendency is for it to spread along the cartilage with involvement of its corresponding rib, and even extension to other ribs. This tendency to spread is especially marked when the disease involves one of the lower ribs whose cartilages form a continuous bridge. Moschowitz[21] said that the usual history of a patient with chondritis could be divided into four stages. During the first the soft-tissue abscess is treated by incision or is allowed to perforate, leaving a sinus. In the next stage laboratory investigation of the persisting sinus usually reveals tuberculosis. In the third stage, the stage of the curette, attempts at local eradication of the sinus are made. Finally comes the "stage of unsuccessful surgery," when multiple sinuses are present. Here wide excision of tissue is useless unless all of the cartilage in the involved area is removed from rib to sternum. As was repeatedly observed in his cases it was not the specific nature of the infection but rather the reaction of the specific tissue that made for chronicity. At secondary operations no evidence of tuberculosis could be found when all of the diseased cartilage had been removed at the first, but the remaining end of the cartilage was found to be denuded of its perichondrium and there was chronic chondritis. This tendency to chronicity can be best explained by the poor blood supply, the fact that the arteries are end arteries, and by the delicacy of the perichondrium. This last point was especially remarked upon by Moschowitz, who felt that the presence of a drain was sufficient to injure this tissue.

The diagnosis of this condition is especially important as it may be confused with typhoid chondritis, pyogenic infection, or syphilis. In the local examination of the part there is nothing specific. The history, the demonstration of the tubercle bacilli in smears or by growth on special culture media, or by guinea-pig inoculation, and the demonstration of tuberculosis elsewhere in the body are the points to be made.

The treatment of tuberculous chondritis needs great emphasis as it is usually notoriously inadequate. If conservatism is to be practiced then one

must be thoroughly conservative and depend upon general hygienic and heliotherapeutic measures. From a study of the recent literature, however, it seems evident that the only real hope for success lies in the addition of radical surgery. Although it was recognized by some that complete excision of cartilage was necessary it was not until 1918 when Moschowitz published his paper that the subject was clearly presented. Before that time most surgeons had been content to do local excisions of diseased cartilage, or a more radical resection, but still leaving exposed cartilage in the operative wound. These procedures were not infrequently temporarily successful but almost invariably recurrence ultimately occurred. In more recent years the teachings of Moschowitz have been widely followed and with a great increase in the percentage of cures. He showed the importance of complete removal of all of the costal cartilage in which the disease occurred, with partial resection of the bone at either end. Involvement of any rib below the fifth calls for subperichondrial resection of all of the lower costal cartilages as there is a continuous bridge between them. Having removed the cartilage the involved soft tissue must be as carefully excised as possible, meticulous hemostasis attended to, and the wound closed tightly. In extensive cases muscle pedicle grafts will be necessary. Drains should not be used in the absence of mixed infection, the accumulation of serum in the wound being combated by the firm pressure of the overlying dressing.

During the last three years I have had the opportunity of treating three cases of localized tuberculosis of the chest-wall. Because of their value in illustrating points discussed in the preceding paragraphs these cases are here reported.

Case I.—E. C., a thirty-year-old white woman, a pupil nurse, first had evidence of pulmonary trouble following an attack of influenza and pleurisy in 1920. She developed a productive cough, lost weight and ran an afternoon fever. Examination showed evidence of pulmonary tuberculosis and she was sent to a sanatorium. After eighteen months she was well enough to resume her nursing, which she continued until 1926, when another attack of influenza followed by pneumonia caused a relapse in her tuberculosis. She was finally admitted to the Blue Ridge Sanatorium June 1, 1928. At that time she had evidence of an advanced bilateral process. She improved after a poor beginning and was doing well until January 28, 1929, when she suddenly developed spontaneously an extensive interstitial emphysema with evidence of mediastinal involvement. After going steadily downhill she recovered rapidly following surgical drainage of the supraclavicular and infraclavicular emphysematous areas. In June of the same year there developed a small inflammatory area over the lower part of the sternum. By the twenty-ninth it had shown evidence of fluctuation and was aspirated. At this time six cubic centimetres of thick yellow fluid were aspirated. No organisms were found. Other aspirations were done and heliotherapy was used without signs of improvement. It was then decided to excise the area. July 24 this was done under local anæsthesia. At that time the process seemed to be confined entirely to the soft tissues over the lower end of the sternum; no communication with the bone could be found. The wound was packed open with iodoform gauze. Examination of the small amount of tissue removed at operation showed a diffuse tuberculous inflammation with large caseous areas and a moderate epithelioid reaction with hæmorrhage, giant cells, and secondary acute inflammation. Healing took place slowly but progressively until only a small sinus persisted,

which gave no evidence of healing. All forms of local treatment and heliotherapy were tried without success. Finally, it became evident that the sinus led down to a deeper structure, probably the costal cartilage. March 1, 1930, under gas and oxygen anæsthesia the old lesion was excised and a focus was found in the cartilage of the seventh rib about an inch from the sternum. This area was excised locally and the wound packed with vaseline gauze. Sections were only made from the soft tissues removed, the cartilage as such was not recognized. The pathologist's report was: "Sections of skin and subcutaneous tissue show apparently normal epidermis but the derma shows marked round-cell infiltration and dense hyalinized fibrous tissue. On one border there is a mass of old granulation tissue which shows round cells and polymorphonuclear infiltration. Beneath this and throughout it are a number of areas resembling tubercles with giant cells and epithelial cells. There is only slight evidence of any caseation. *Diagnosis.*—Tuberculous granulation tissue."

Again she returned to the sanatorium and local measures and heliotherapy were again applied. All of this time her pulmonary condition was showing no change but she had improved to such a point that she was without symptoms except for a slight cough at times and a tendency to develop fever on exertion. It was at last realized that the only chance for cure of the tuberculosis of the chest-wall lay in a radical removal of the lower cartilages. This was done July 8, 1930; the sixth, seventh, eighth, and ninth costal cartilages were excised. Examination of the tissue removed showed many pieces of rib, cartilage and fibrous tissue, and skin. Sections showed normal-appearing epithelium, but the subcutaneous tissue was infiltrated with polymorphonuclear round cells and red blood-cells with many tubercles. There was marked increase of fibrous tissue. Sections of the cartilage and bone showed no evidence of tuberculosis but slight acute and marked chronic inflammation with many giant cells. *Diagnosis.*—Acute and chronic inflammation of skin with tubercles in the subcutaneous tissue. Acute and chronic osteochondritis.

The wound healed quite well, being almost entirely closed except for the site of the old wound by the end of the second week. At this time she began having frequent headaches and generalized dull pains. After three days she showed evidence of meningeal irritation with increased spinal fluid pressure (200 millimetres water) and 146 cells per cubic millimetre but tubercle bacilli could not be demonstrated. She went rapidly downhill and died July 30, just twenty-two days after her operation. Permission for autopsy was refused.

Comment.—This case was of extraordinary interest throughout and it was most disappointing that a final examination could not be made. The origin and course of her spontaneous interstitial emphysema have been discussed in an earlier paper.[22] Apparently, there was no direct connection between her intrathoracic tuberculosis and that of her chest-wall. In retrospect, it would seem that she had a tuberculous focus in her costal cartilage from the beginning and that it was overlooked at the first operation. The inward extension of a soft-tissue tuberculosis to the cartilage is not on record where there has been excision of the process without damage to the underlying cartilage. That no damage could have been done to the cartilage at the first operation on this patient is certain as the procedure was confined to exploring the inflammatory process which was located over the lower part of the sternum. The first operative procedure would seem to have been adequate though an attempt at closure of the wound would have been better. At the second operation when cartilage was found to be exposed and diseased the radical procedure carried out at the last operation should have been done. Failure to do so was partly due to the patient's fear of an operation of any extent and to my own feeling that a local procedure might suffice. The fatal outcome in this case was probably associated with the operation. She had an advanced pulmonary lesion and the addition of extensive trauma was sufficient to cause a flare-up in her pulmonary lesion and spread to her meninges, or brain. Such a fatal ending was reported by Moschowitz in one of his cases. Whether such an operation should be urged upon a

patient with the marked pulmonary involvement that this patient had is a debatable question. As can be seen from this report conservative treatment was followed for a long time. After months of having a small draining sinus this patient became so depressed at the thought of its persistence, even though it was neither painful nor in any noticeable position, that she said that she would rather die than live with it ever present. Although she had widespread involvement of her lungs the process had reached a semi-quiescent state, she had no tubercles in her sputum and with rest ran no fever. She was to be discharged from the sanatorium when she begged to have another attempt made to eradicate her chest-wall lesion.

Case II.—S. M. H., a thirty-nine-year-old white railroad fireman, was admitted to the University of Virginia Hospital May 26, 1930, because of draining sinuses of his right chest-wall. Four or five years before admission he had developed a right-sided pleurisy with effusion and was in bed for five months. Eighteen months later he worked for a short time and then developed a tuberculous cervical adenitis, also on the right side, which responded to simple drainage. In December, 1928, he was admitted to the medical service of the University of Virginia Hospital, at which time he was found to have a right cervical adenitis, a large abscess of the right chest-wall, a greatly thickened pleura and röntgenographical evidence of an old tuberculous process of the right apex. Aspiration of the abscess revealed clear yellow fluid which contained tubercle bacilli. He returned home and under general hygienic treatment improved in every way. The abscess opened spontaneously and drained clear fluid from the sinus which had developed at the site of the original aspiration. Later, two other sinuses formed near the sternum and were used by his doctor for purposes of irrigation. Upon return to the hospital in May, 1930, he was found to have evidence of an old healed right cervical tuberculous adenitis, retraction of the upper half of the right chest, and a chronic abscess occupying the right chest-wall with old sinuses located at the anterior axillary line over the fourth rib, near the sternal end of the same rib and over the sternal end of the third rib. There was free communication between these with evidence of a large central extrapleural cavity. Röntgenographical examination of the chest showed evidence of an old tuberculosis of the right apex, marked thickening of the entire right pleura and a small area of rarefaction in the centre of a mass of increased density corresponding to the sternal end of the right fourth rib.

May 29, under gas and oxygen anæsthesia, an incision was made connecting the three sinuses. This opened into a large abscess cavity which extended under the pectoral muscles, and involved parts of the cartilages of the third and fourth ribs which were ragged in appearance. The sternal end of the fourth rib showed evidence of necrosis. The intervening soft parts were almost cartilaginous in consistency. There was a rather large amount of thin purulent fluid material. All of the cartilage of the involved ribs together with the terminal two inches of bone was resected. The intervening soft tissues were excised as completely as possible but the pleura was not exposed due to the greatly thickened endothoracic fascia.

Examination of the tissue removed at operation showed small pieces of roughened cartilage, of normal-looking rib, a piece of rib with an irregular cavity containing soft translucent tissue and pieces of skin and fibromuscular tissue. Section of the soft tissues showed much dense fibrous tissue with round-cell infiltration and large portions of a more cellular granulation tissue, showing numerous small tubercles. In the latter portion were also numerous polymorphonuclears. A few areas of necrosis were present. Section of the cartilage showed inflammation of a somewhat atypical nature but with no evidence of tuberculosis. The bone, due to a misunderstanding, was not sectioned, and the specimen lost.

The patient made a good recovery from his operation. The wound drained freely at first but drainage decreased rapidly under daily dressings and ultra-violet-light therapy until his departure from the hospital nineteen days after operation. At that time the wound was mainly healed except for the lowermost portion, from which there

escaped seropurulent fluid. The patient was allowed to return home with the understanding that he would receive ultra-violet-light therapy and have other proper care.

After returning home he continued to improve. His wound was solidly healed by November and remained so until the following April. At this time a sinus reappeared. His general condition had continued to be good. Since then I have been unable to get in communication with him.

Comment.—The origin in this case seems definitely to have been in the lymphatics of the chest-wall. As a result of his pleurisy the lymphatics became involved but did not give rise to the chest-wall abscess until the intrapleural disease had become dormant. The appearance of the sinus at the site of the aspiration is typical and illustrates the importance of using proper technic as previously described. The delay in healing was probably due to a combination of circumstances, mixed infection, incomplete removal of diseased tissue, and failure to fully obliterate dead space.

CASE III.—J. M., a white taxi driver of thirty-two years, was first seen in the Chest Clinic of the Episcopal Hospital, Philadelphia, February, 1931. During the course of his routine chest examination it was noticed that he had an oval swelling in his lower chest, overlying the eighth rib at its costochondral junction. He had noticed this swelling for a few weeks but because of lack of pain had said nothing about it. In 1928, this patient had been found to have a bilateral pulmonary tuberculosis and had been sent to a sanatorium, from which he had been discharged as a quiescent case in May, 1930. Since that time he had been working, as a taxi driver, with no symptoms except for a slight morning cough.

Examination of the chest showed a typical cold abscess in an early stage occupying the region above described. It was about two inches in greatest diameter, was soft and deeply fluctuant, not tender and the overlying skin was normal. There were also signs of disease at both apices, with moderately coarse râles after cough, and slight dullness.

Aspiration of the swelling through the surrounding edge of normal tissue gave a clear, straw-colored fluid which contained no pus and no bacteria. Guinea-pig inoculation also was negative.

He was admitted to the Episcopal Hospital February 25. A röntgenogram of his chest showed evidence of an old bilateral apical tuberculosis but no evidence of rib involvement was seen. February 26, under local anæsthesia, an incision was made over the dome of the swelling starting an inch lateral to it and extending an inch medial to it. The mass was found to be an abscess arising from the tissue immediately overlying the costal cartilage near the costal junction. In excising it a small opening was made in its wall and a creamy pus escaped. The wound was cleaned and then the distal inch of the rib and the proximal inch of the cartilage were resected and their ends covered with bone wax. It was thought then that the process was arising from the perichondrium. The muscles were carefully approximated as well as the subcutaneous tissue and skin. A small rubber dam drain was inserted in the outer angle of the wound and a firm dressing of gauze was applied. Convalescence was uneventful, the wound healing by primary intention except at the site of the drain. He was discharged March 7 nine days after operation.

Microscopical examination of the tissue removed at operation showed no involvement of the rib or cartilage but tuberculous granulation tissue. It could not be determined whether it arose in the perichondrium, or the overlying connective tissue.

The patient now has a small scar which gives him no trouble and shows no evidence of breaking down. His general health has continued to be good.

Comment.—Prompt detection of the abscess in this case was due entirely to a routine examination. It was in a very early stage and most suitable for operative intervention. The rapidity with which healing took place and the fact that the remaining cartilage did not become involved suggest that the process was completely removed and that the

cartilage had not been primarily affected. There seems to be no evidence here of lymphatic extension from a deeper focus.

Usually such a case would not reach a surgeon until after the abscess had been repeatedly aspirated or had spontaneously opened; then the story of healing would not have been so smooth.

Summary.—There is a striking difference in the number of cases of localized chest-wall tuberculosis seen in hospital practice. This can be accounted for by the difference in attitude of the doctors referring patients to surgeons.

The process may arise by extension from foci in the lymphatics of the chest-wall, or as a hematogenous infection.

In order of frequency the bony ribs come first, the sternum, and soft parts next, and the cartilage last.

Diagnosis can rarely be made before the cold abscess appears. Examination of its contents will almost invariably settle the question.

Treatment must be general and local. Excellent results have been obtained by radical excision well beyond the limits of the involved tissue, removal of all exposed cartilage, and air-tight closure. Drainage should be used only in cases with mixed infection.

Three new cases of localized chest-wall tuberculosis are reported.

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THE FULL-THICKNESS SKIN GRAFT

ITS FIELD OF APPLICABILITY AND TECHNICAL CONSIDERATIONS*

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Although evidence indicates that the ancients made use of this form of skin grafting, the earliest authentic record was by J. Mason Warren, in 1843. Wolfe, in 1875, introduced the method to ophthalmological literature, while Kraus, a year later, called attention to its possibilities in general surgery. The more modern aspects of the subject have been developed largely by J. Staige Davis and V. P. Blair. While, since Warren's first report, this method has been used frequently, it still remains a surgical resource of great value to a relatively small group of surgeons. Therefore, I would like to call attention again to its possibilities and to enumerate some of the problems, many of a technical nature, that have been encountered.

Inasmuch as the success of a full-thickness skin graft depends largely upon an almost perfect aseptic technic, it may be stated that this type of graft should be placed only on a fresh surgical wound and that its use for granulating wounds is inadvisable. Its field of applicability is therefore limited to a group of cases which present a defect of skin and subcutaneous tissues immediately following surgical excision of a pathological condition. These may be divided into several classes; namely, following excision of healed cicatricial contractures caused by burns or trauma, after plastic or destructive operative procedures to prevent cosmetic defect or contractural deformity, to replace skin loss following excision of surface tumors or blemishes, to furnish skin for the clefts in the operation for congenital or acquired syndactylism, and to replace hair-bearing skin, as an eyebrow.

The convalescence of a patient with a large granulating wound may be greatly shortened by the early application of Thiersch grafts, a point stressed by Lyle. Besides diminishing the extent of underlying fibrosis, which, in itself, is most important, early Thiersch grafting curtails the period of convalescence and the number of painful dressings. At a later date, if contractural deformities develop, the full-thickness skin graft may be used following excision of the scar.

In the selection of the type of skin graft to be used in a particular case, the surgeon must take cognizance of a number of factors. There are numerous conditions in certain parts of the body which require for their correction more underlying tissue than a full-thickness graft can supply. Under such circumstances, the pedicled skin flap offers greater possibilities. Certain regions, as the neck and axilla, are so constituted anatomically as to lend themselves poorly to prolonged immobilization and firm, even pressure, two

* Read before the New York Surgical Society, May 11, 1932.

factors which are so necessary for the success of the full-thickness graft. In the neck, the constant motion of the thyroid cartilage in the act of swal-

FIG. 1.

FIG. 2.

FIGS. 1 and 2.—This boy, eight years of age, was admitted to the New York Hospital six months after he had sustained severe burns of the legs when an Indian suit which he was wearing caught fire. He was taken to a hospital soon after the accident, where he remained for six months. There contractures of both popliteal spaces were allowed to develop. The child appeared chronically ill and screamed with pain when dressings were attempted. There was a large granulating area in each popliteal space. The knees were flexed to a right angle. The legs were placed in traction. On October 16, 1929, following the preparation of the granulating areas, a pedicled flap was raised from the posterior aspect of the left thigh, the pedicle being situated over the outer aspect of the knee. The scar tissue in the left popliteal space was excised and the flap placed transversely into the defect. The flap measured one and a half inches by three and a half inches. A plaster splint held the knee in extension. The distal one inch of this flap sloughed.

lowing accounts for the reported instances of necrosis of the graft at this site. In the axilla, the irregular depth contour of the wound following excision of

a cicatrix makes firm, even pressure difficult. In other regions, as the back of the neck, the forehead and face, and parts of the torso, the full-thickness graft can be used with excellent chances of success. However, this form of graft finds its greatest field of usefulness in extremity surgery. To cover defects in the popliteal space, the front of the elbow, the forearm and leg, and both aspects of the hand, the surgeon has in the full-thickness graft a

FIG. 3.—Three weeks later, the pedicle of the flap was divided and sutured into place. Thiersch grafts were then applied to the defect along the inner side where the flap had sloughed. At this same sitting, a tubed flap was made on the anterior aspect of the right thigh. This was subsequently "waltzed" to the inner aspect of the right knee in preparation for use in the right popliteal space. However, the house surgeon, in removing the bandage one day, accidentally divided the flap in two; so that this procedure had to be abandoned. The granulating area in the right popliteal space and the contracture are clearly shown.

most valuable surgical recourse. In addition to supplying adequate tissue, it has the added advantage of a one-stage procedure. Even in extremity surgery, certain minor limitations to its use must be considered. For instance, a full-thickness graft will not unite to bone, unless a layer of periosteum is present. On the flexor surfaces of the fingers, this form of graft will very

often not succeed if placed upon exposed tendons. An intact tendon sheath is most desirable.

There are other considerations, more remote in point of development, which must also be analyzed before the surgeon makes use of a full-thickness graft. These involve future shrinkage, changes in color, the development of heavy scars at the edges and the growth of hair. With regard to shrinkage, it has been my experience that, if the graft "takes" perfectly with a minimum loss of surface epithelium, the contraction will not be more than would follow the healing of a pedunculated flap of similar size. In certain regions, allowance must be made for any shrinkage with a view toward future func-

FIG. 4.—One month later, a full-thickness graft taken from the left buttock was applied to the inner half of the left popliteal space marking the region where the original pedicled flap had sloughed. This graft measured two inches square. It was not perforated. Xeroform-rubber sponge dressing was applied. First dressing was done on the twelfth post-operative day. The graft "took" entirely. One month later the granulating area in the right popliteal space was covered with Thiersch grafts. The patient was then discharged and returned one year later. The photographs indicate the contracting scar in the right popliteal space and the soft pliable skin in the left popliteal region.

tion. For instance, when a Wolfe graft is placed on the dorsum of the hand, the fingers should be placed in flexion during the period of healing in order to prevent future loss of function. In certain locations, Blair speaks of doubling back the skin bordering the defect at the time of operation in order to compensate for expected contraction. On the hand, splints used for two or three weeks will help control contraction.

With regard to late changes in color, numerous interesting observations have been made. In true blonds, very little, if any, later pigmentation occurs. Brunettes show a much greater tendency to pigmentary changes. This is

more prone to occur if superficial exfoliation of the uppermost epithelial layers takes place. A good "take" without this surface blistering shows grossly very little change from the normal skin texture of the original source of the graft. Finally, full-thickness grafts have a tendency to develop a "shiny" appearance, which must be considered when using the method for face defects.

Not infrequently, a heavy scar will develop along the edges of the graft.

FIG. 5.

FIG. 6.

FIG. 5.—A free full-thickness graft taken from the lower lumbar region, and measuring three by five inches, was placed in the right popliteal space after excision of the contracting scar. No perforation of the graft was done. Xeroform ointment and rubber sponge dressing. Photograph indicates a tiny slough near the outer inner angle.

FIG. 6.—This indicates the final result. The photograph was taken two and a half years after the last operation. The skin in each popliteal space is soft and pliable, and is not pigmented. There is normal function in the knee-joints.

This may occur after a perfect "take." It is difficult to explain this remote development, unless the reason may be the indefinite one that causes some individuals to form keloids after simple incisions. Needless to say, one cannot foretell this eventuality.

I have noted, in almost every instance, that, three or four months later,

a thin layer of fatty tissue is deposited beneath the graft, and a previously depressed area fills up and rises to the level of the surrounding skin. Thus, the full-thickness graft possesses another important advantage. Inasmuch as the majority of hair follicles in a successful "take" will grow hair, the surgeon must choose non-hair-bearing skin, unless hair is desired. This is important.

The most recent study of the histology of skin grafts is by Harold Neuhof, in his monograph, "Transplantation of Tissues." I believe that a clear understanding of the healing processes and tissue changes is so important that a brief summary of his findings is indicated. Within five or six hours after transplantation, there is an exudate

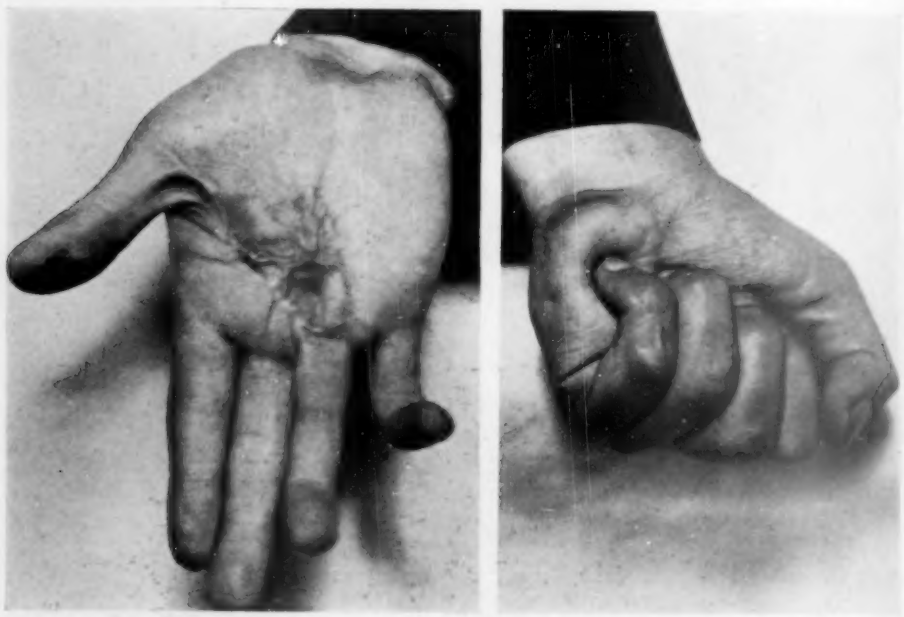

FIG. 7.—This patient caught his left hand in a machine on September 18, 1929, producing an injury in the palm. He was taken to a hospital where an operation was performed the following day. The wound became infected, necessitating two subsequent operations. The wounds healed after twelve weeks. The patient presented an irregular contracting scar in the palm of the left hand, stretching from the base of the ring finger to the base of the thumb, pulling the thumb toward the palm. There was bony ankylosis of the proximal interphalangeal joint of the little finger due to a badly united fracture. The ring finger was held in partial flexion and there was marked impairment of active flexion in the middle and ring fingers. On July 1, 1930, the entire scar in the palm of the hand was excised. Extensive scar tissue binding the various flexor tendons together was visualized. This was completely removed. A sleeve of parotenon fat taken from the palmaris longus tendon was placed around the flexor profundus tendons of the ring and middle fingers. The defect was then covered with a free full-thickness skin graft taken from the anterior chest-wall. The hand was placed on a specially prepared aluminum splint with the fingers in extension and wide abduction. The graft was not perforated. Xeroform ointment-rubber sponge dressing was applied. The first dressing was done on the eleventh post-operative day. A small area of necrosis developed in the centre of the graft. This pictures the result after two years, and illustrates the thick peripheral scar as well as a keloid formation at the point of necrosis.

of fibrin from the underlying wound fixing the transplant in place. This fibrin layer soon becomes infiltrated with leucocytes and fibroblasts and disappears gradually, being replaced by a richly vascular connective tissue containing round cells. The granulation tissue has changed into an organized membrane at about two weeks. Within a few hours after the grafting operation, leucocytes of the fibrin layer migrate into the interstices of the graft and are also found in the lumina of its empty blood-vessels. Most of the vessels in the transplant degenerate. By injection experiments, vessels have been

demonstrated in grafts on the third day. I have demonstrated this point, clinically, by obtaining bleeding from a free full-thickness graft after forty-eight to fifty-six hours by scarifying its surface. The newly built vessels arise by a budding of the capillaries in the fibrin layer and the buds often extend directly into the vessels of the graft. The latter histological finding is evidence in favor of suturing full-thickness grafts under some tension so as to favor keeping open the cut ends of blood-vessels and lymphatic channels.

Degenerative processes begin, and by the third or fourth day the epidermis with the upper rete layer is lost. At an early date, vacuolization of the surface of the graft is evident. Hand in hand with the degenerative processes, regeneration goes on and it is usually so energetic that in six or eight days, the entire transplant is covered with new epithelium. The degeneration extends to the cutis, also. Padgett, working in

FIG. 8.

FIG. 9.

FIG. 8.—The scar on the chest-wall marking the doner site for the full-thickness graft.

FIG. 9.—This patient, when first seen on January 7, 1931, presented a large neurofibroma on the antero-internal aspect of the left leg which he had had for twelve or thirteen years. The tumor was completely excised, leaving an oval defect measuring three inches in diameter, and two and a half inches in length. In order to completely eradicate the growth, a small piece of periosteum was removed from the tibia. A full-thickness skin graft taken from the anterior aspect of the same thigh was placed in the defect. It was not perforated. Xeroform ointment-rubber sponge dressing. The graft "took" completely with the exception of the region which covered the tibia where the periosteum had been removed. The photograph indicates the result after fifteen months, and shows that the area which had been previously depressed is now level with the surrounding skin due to the deposition of fat.

Blair's clinic, found that his sections did not show as much degeneration of surface epithelium or cutis and corium as is usually described.

Technic.—It is probably wiser to completely excise a cicatrix than to make relaxing incisions only. Naturally, if the area produced by total excision of the cicatrix were to be too extensive, such a procedure would not be feasible. In extremity surgery, the use of an Esmarch bandage is an

FIG. 10.—This patient received a severe injury to the right hand on November 10, 1930, when it was caught in a silk machine. He was treated in a hospital out of town for one and a half months. Five months after the injury examination showed a thick ridged scar extending from the wrist to the proximal phalanx of the ring finger, producing a contracture of the entire palm, drawing all the fingers together toward the middle of the palm. X-ray revealed a healed fracture of the proximal phalanx of the little finger united in poor position. The photographs indicate the extent of function before operation.

FIG. 11.—On March 24, 1931, the entire scar was excised, thus permitting complete extension of the fingers. The defect measured five by three inches. A free full-thickness skin graft taken from the chest-wall was applied. The graft was not perforated. The hand was placed on a specially prepared aluminum splint with the fingers extended and widely abducted. Xeroform ointment-rubber sponge dressing. The graft "took" completely. The first dressing was done on the thirteenth post-operative day. The splint was worn for three weeks. The photographs indicate the thick scar along the outer distal aspect of the palm. In addition, the deep pigmentation is noteworthy. This was expected because the patient is very dark complexioned. The improvement in function is noteworthy.

added advantage, because it permits of more rapid excision of the cicatrix and diminishes, to a large extent, tissue trauma. After excision of the scar,

FIG. 12.—This patient injured his left hand on August 31, 1931, when it was caught in a bread machine. The patient was taken to a hospital where the wounds were sutured. A mild infection developed producing an extensive cicatrix as indicated in the photographs. This scar prevented extension of the little, ring, and middle fingers and full abduction of the thumb.

the Esmarch bandage is removed and bleeding is controlled. The capillary bleeding that always occurs can usually be controlled by having an assistant apply firm, even pressure with warm sponges while the surgeon removes the

FIG. 13.—On October 27, 1931, the entire scar was excised. Scar tissue was found extending into the palm, binding the various digital nerves together and running into the muscles of the thenar eminence. The defect was covered by a non-perforated full-thickness skin graft taken from the chest-wall. The hand was placed on an aluminum splint with the fingers widely abducted and extended. Xeroform ointment-rubber sponge dressing. Aside from superficial exfoliation of the surface epithelium, the entire graft "took" without incident. The photographs indicate the return of complete function, and the peculiar mottled pigmentation in a patient who is moderately dark skinned.

graft from the donor site. Before the graft is applied, the wound should be absolutely dry. This is probably the most important feature of the opera-

tive technic. In securing bleeding points, triple-zero plain catgut is used. Fear of possible harm to the graft by burying many tiny knots of catgut in the wound bed should not deter the surgeon from obtaining absolute hæmostasis. I have not seen any complications which could be ascribed to this practice.

It is advisable to undermine the edges of the wound to be grafted in order to obtain more accurate edge-to-edge apposition. This manœuvre also helps to diminish future contraction of the graft and probably lessens the likelihood of a heavy peripheral scar.

A pattern accurately reproducing the size and shape of the wound is next made. Numerous methods have been proposed to expedite this step. Blair uses tinfoil. Others use rubber dam. For the past three or four years, I

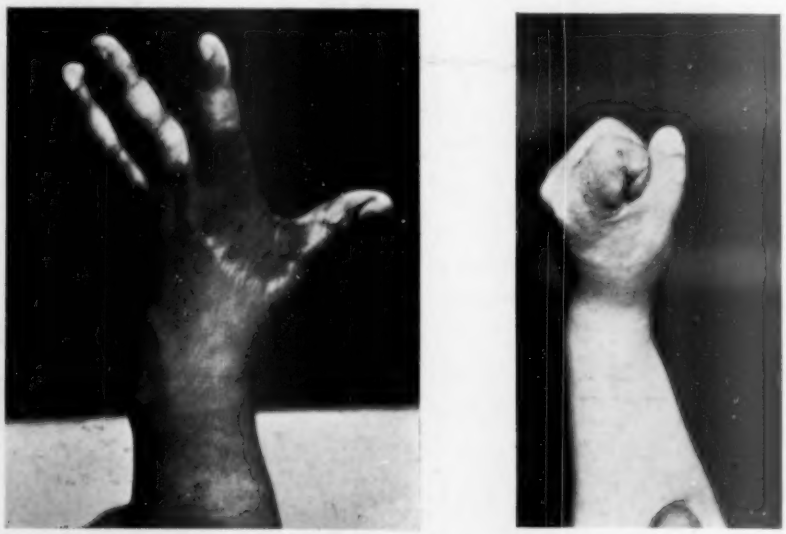

FIG. 14.—This child, two years of age, burned his left hand when a hot iron fell on it. The burned area healed producing a syndactylism between the thumb and index finger, with obliteration of the first web and part of the web between the index and middle fingers. The entire scar was excised, thus freeing the webs between the involved fingers. The hand was then placed on a specially prepared aluminum splint with the fingers widely abducted. A non-perforated free full-thickness skin graft taken from the left thigh was placed into the defect and xeroform ointment-rubber sponge dressing applied. The first dressing was done on the eleventh post-operative day. The graft "took" completely. The splint was worn for two and a half weeks. The pigmentation indicated in one photograph is an artefact. The grafted area is hardly distinguishable from the surrounding skin, as indicated in one of the photographs.

have been using stiff paraffin mesh gauze with the idea that the perforations in the gauze aided the surgeon in visualizing more clearly the underlying wound while cutting the pattern. In the December, 1931, issue of the Archives of Surgery, Davis and Kitlowski described another method which makes use of perforated cellosilk and brilliant green dye to outline the size of the pattern. The skin from which the graft is to be obtained is painted with 3½ per cent. iodine and is washed off with alcohol. The pattern is laid on the skin, epithelial surface up, and the outline is most accurately marked out with the point of a toothpick dipped in methylene blue or brilliant green solution. Using a very sharp small knife, the painted outline is

then incised down through the full thickness of the skin. Believing that any form of trauma, however slight, will lessen the chances for a successful

FIG. 15.—This patient caught his left hand in a dough roller producing a severe crushing injury of the index, middle, and ring fingers. He was admitted to the New York Hospital soon afterwards, presenting extensive lacerations with "spreading effect," involving the anterior aspects of these three fingers. The tendon sheaths were opened and the tendons exposed for a distance of one and a half inches. The patient was operated upon soon after admission. The wounds were thoroughly debrided and sutured *loosely*. Active motion was started the next day and the wounds healed without incident. The photographs indicate the appearance of the fingers on the tenth post-operative day. The scars subsequently produced a mild flexion contracture of the middle and ring fingers.

"take," a technic has been developed which permits of no grasping of the graft by any instrument. Although this is rather tedious, the results have

justified this feature. A tiny hook is made to catch one corner of the graft, and, with this as a tractor, the cutting of the graft is initiated. As its removal proceeds, additional hooks may be placed at cardinal points to facilitate the operation. The undersurface of the skin should be free of fat and show

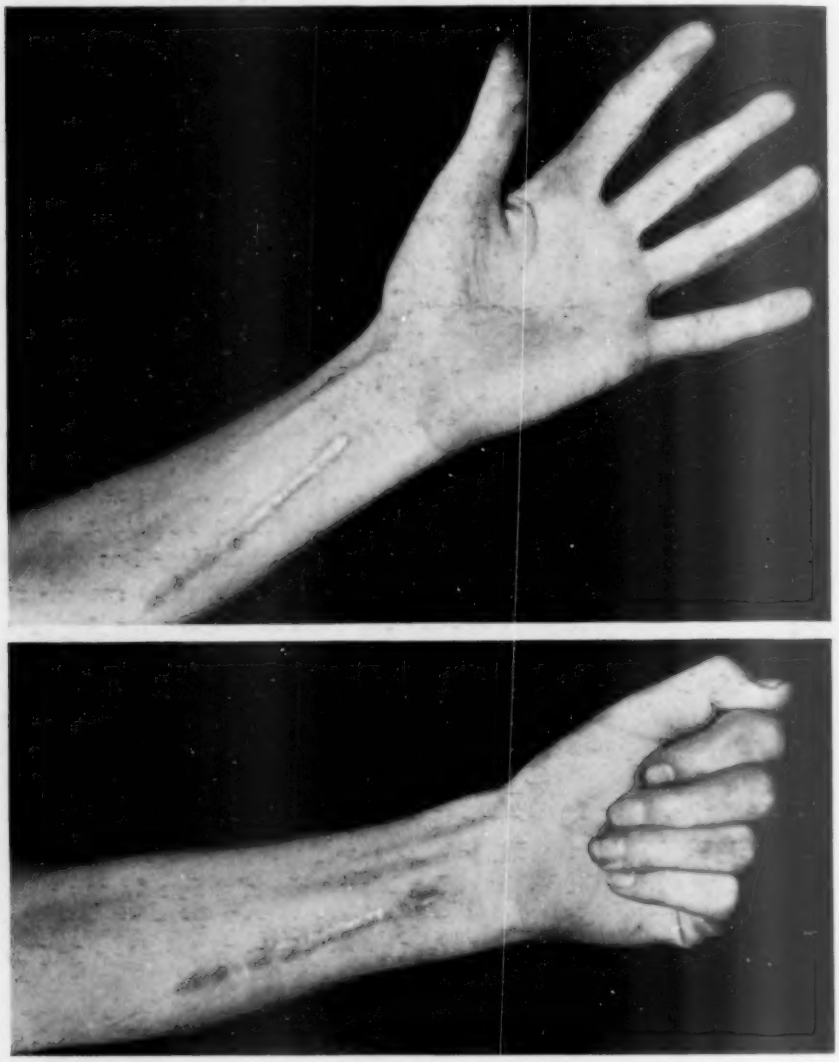

FIG. 16.—Accordingly, six months later these scars were excised without exposing the tendons. Free full-thickness skin grafts taken from the front of the forearm were inserted into the defects. The fingers were placed in extension on tongue depressor splints, and xeroform-rubber sponge dressings were applied. The first dressing was done on the seventh post-operative day. Each graft "took" completely. The fingers were immobilized for two and a half weeks. The photographs indicate the lack of pigmentation in a patient who is blond.

white and stippled with tiny depressions. After its removal, the graft, still held by one or two hooks, is placed raw surface downward, on a warm, moist gauze pad. All these precautions are taken because I feel that a tech-

nic which tends to eliminate trauma will obtain the highest percentage of perfect "takes," provided asepsis is rigid and hæmostasis complete.

FIG. 17.—This patient received a severe crushing injury six months before. This produced an extensive contracting scar on the dorsum of the left hand which had drawn the fingers in hyper-extension, producing pathological dislocation of the metacarpo-phalangeal joints of the four fingers. The anterior aspect of the hand was negative. At operation the entire constricting scar was excised. The metacarpo-phalangeal joints were brought into flexion only after the collateral ligaments were divided. The entire area was covered with a perforated full-thickness skin graft taken from the chest-wall. The hand was placed on a wire splint with the fingers in flexion, and xeroform ointment-marine sponge dressing applied. The photographs indicate the appearace of the graft on the eleventh post-operative day when the first dressing was done. There is visible a small area in the centre of the graft which indicated a spot of necrosis. The remainder of the graft "took" without incident. The hand was subsequently placed in a reversed banjo splint in order to apply elastic traction to the fingers. At the time of discharge from the hospital there had been marked improvement of function.

The graft is next placed in the wound bed, care being taken to fit it in according to pattern. Because such care has been exercised in obtaining

hæmostasis, perforation of the graft is often unnecessary. In two instances, scars developed at the sites of perforation. However, should the surgeon be unable to obtain complete hæmostasis, perforation would be indicated in order to prevent the formation of blood-clots beneath the graft. The latter complication is one of the most common causes of necrosis.

Using fine horsehair on fine skin needles, the surgeon places a few sutures at cardinal points to anchor the graft in place. The remaining edges are approximated with a continuous stitch of horsehair. Accurate apposition of the skin edges is important. It makes for a neater scar and additional source of blood supply during the first eight or ten days. The entire surface is then covered with three thicknesses of gauze impregnated in 2 or 3 per cent. xeroform ointment. Blair recommends the use of this medication because it is supposed to be antagonistic to staphylococci which are present in skin and skin grafts. This is covered with several thicknesses of smooth gauze. Over this is placed a large moistened rubber bath sponge. A sterile bandage is then firmly applied. Considerable skill is required in applying the proper amount of pressure. If the pressure is too great, ischæmia and death of the graft will result. If the pressure is insufficient, blood-clots may form, jeopardizing the graft. On numerous occasions, I have used the marine sponge, as recommended by Blair. However, the results in these cases were not nearly as satisfactory as with the rubber sponge. Perhaps the reason for this difference is the fact that the rubber sponge possesses greater elastic resiliency and maintains this quality for a longer period post-operatively than the sea sponge. This difference has become so evident that I have given up the use of the sea sponge. It is important, when using the rubber sponge, not to apply a very voluminous dressing for fear of making the grafted region air-tight. If air is excluded, maceration of the graft may take place.

Absolute fixation of the grafted area during the period of healing is most desirable, especially in extremity surgery. Extended use of splints which immobilize contiguous joints greatly increases the likelihood of a perfect "take." In covering defects on the hand and fingers, fixation is best obtained by the use of splints made specially for each individual case. These are easily cut out according to pattern from rigid sheet aluminum. They are sterilized and applied at the operating table. They should be worn for at least three weeks.

The resulting wound following excision of the skin graft may be closed by undermining the edges and approximating them with silkworm-gut sutures. If tension is present, necrosis of the edges may be avoided by making numerous small releasing incisions in the skin surrounding the sutured wound. This procedure has proven most valuable. If the defect is a large one, it may be partially closed and the remainder is then covered with Thiersch grafts.

If the surgeon is satisfied with the asepsis of the operation, the control of bleeding and the fixation of the grafted area, he need not disturb the

dressing for two to two and a half weeks. There is no great harm in looking at the graft on the eighth or ninth day provided the pressure bandage is replaced in the same manner as at the original dressing. If the pressure dressing is removed too early, blisters form on the surface of the graft and these are prone to infection. The latter complication predisposes to ulceration of the graft. I have found it inadvisable to remove the tops of these blebs for this reason. Should infection develop, boric acid wet dressings are used. The pressure bandage should be maintained for a period of about three weeks, while the immobilizing splint is discarded after the third or fourth week. The grafted area should be protected from possible mechanical or thermal injury for about six weeks.

It is interesting to follow the return of sensation in these grafts. Apparently, the cutaneous nerve supply is derived from the surrounding skin, the direction of growth being in a centrifugal manner. A zone of hyperæsthesia of the skin immediately adjacent to the graft is noted for some time. Tactile sensation returns first and spreads from the periphery of the graft to the center. It is first noted about the sixth week. Pain sensation returns next, to be followed by temperature sense. In large grafts, complete return of sensation may not be elicited before a year or more after the operation. After six months, sensation in the small and medium-sized grafts is the same as that of the surrounding skin.

CONCLUSIONS

(1) The full-thickness skin graft has a fairly wide field of applicability. It should be reserved to cover fresh surgical defects and should not be used for granulating wounds.

(2) The pedicled skin flap should be used when the local condition requires more underlying tissue than a full-thickness graft can supply.

(3) There are numerous features in the use of this type of graft which the surgeon must recognize. These include the great probability of necrosis if placed over bare bone or tendon, future shrinkage, changes in color, the development of heavy scars at the edges, and the growth of hair.

(4) The technic of the operation is a most exacting one. The essential details include complete excision of scar tissue, rigid asepsis, complete hæmostasis, an operative technic which strives to eliminate any form of trauma to the graft, the application of firm, even pressure over the grafted area, and complete fixation of the part by the use of appropriate splints.

(5) Careful attention to the details of the post-operative care increases the chances of a successful "take."

(6) Finally, attention is again called to this most valuable type of skin transplantation, which merits more extended use than is now accorded it by the surgical profession at large.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

STATED MEETING HELD APRIL 27, 1932

The President, Dr. John Douglas, in the Chair

FRACTURE OF THE SURGICAL NECK OF THE HUMERUS

Dr. Ralph Colp presented a woman, forty years of age, admitted to the Beekman Street Hospital, November 7, 1930.

On the day of admission, the patient, an obese woman of forty years, slipped and fell down ten steps, striking her right arm against a wall. Following the accident, she was unable to move her right arm and experienced excruciating pain around the region of the shoulder. When brought to the hospital, crepitus and a false point of motion of the upper extremity of the right humerus in the region of the surgical neck were elicited.

X-ray revealed a fracture through the surgical neck with considerable over-riding. (Fig. 1.) The arm was immediately put up in traction with ten pounds of weight. Check-up examination three days later revealed the head markedly rotated so that it was necessary to change the axis of the shaft a good 30° above a right angle. The direction of the pull was changed to correspond with this and twenty-five pounds were applied for four hours.

The following day, the check-up X-ray was still unsatisfactory and direction of the pull was changed to one of extreme abduction with fifteen pounds. This resulted in no change. One week after admission, an attempt was made under anæsthesia to reduce the fracture with fluoroscopical control, but no change could be made in the position of the fragments. November 26 an open operation under general anæsthesia was done. Incision between the deltoid and the pectoralis revealed the upper fragment, which consisted of the head and small part of the neck, rotated upward, forward and outward. The distal fragment was drawn up and pulled alongside of it so that it was lateral in position. No callus was visible. The fragments were reduced by manipulation and jammed one into the other and a three-inch ten-penny nail was driven from the distal fragment into the proximal one firmly utilizing the two. The arm was placed in abduction and external rotation, and a plaster spica was applied. Check-up X-ray after operation showed excellent position. (Fig. 2.)

Forty-six days after operation, X-ray showed callus about the fracture. No evidence of reaction about the nail. The plaster was then removed; firm clinical union was present. The arm was put up in traction and suspension for four days. Ten days later, she complained of discomfort in the right hand with swelling of the entire extremity and limitation of the flexion of the fingers. The condition suggested an acute arthritic process. Active abduction of the arm was limited to 45°, external rotation was restricted and internal rotation limited to 50°. Two weeks later, however, the swelling had subsided, and although there was some limitation of motion at the shoulder, the patient was discharged. When last seen, April 15, 1932, about one year

and seventeen months after operation, motion was practically normal in all directions and there were no complaints.

Dr. Clay Ray Murray remarked that fractures of the surgical end of the humerus which fail to reduce readily by traction can be easily attacked by open reduction if proper equipment and facilities are at hand. Where such facilities are not at hand, or where the patient's condition renders operation dangerous, the use of the Kerschner pin through the lower humerus with balanced traction exerted directly upward (toward the ceiling) with the patient supine, will often give excellent reduction of extreme deformity,

Fig. 1.—(Case I.) Fracture of the surgical neck of the humerus taken before operation.

Fig. 2.—(Case I.) Fracture of the surgical neck of the humerus taken seventeen months after operation.

where skin traction, or any traction in abduction or at the side, will fail. In late cases where open reduction is attended by considerable violence, if manipulative reduction, after freeing of the fragments from the soft parts, is attempted, the pin traction will often accomplish the reduction of the freed fragments with remarkable ease and, of course, without the additional trauma of manipulation. Doctor Murray cited a case in which the shaft of the humerus punctured the deltoid muscle in which the Kirschner wire put through the humerus facilitated reduction after the open procedure.

DIVISION OF FACIAL NERVE AT STYLOMASTOID FORAMEN

Dr. Ralph Colp presented a Negro woman, thirty-eight years of age, who was admitted to the Beekman Street Hospital May 12, 1931.

During an altercation with another woman, she had been stabbed with a paring knife behind the left ear. Immediately she felt her mouth twist and could only open one side of the mouth. She never had any paralysis of the face before. She was immediately brought to the hospital. She was a well-developed colored female with a wound of the left mastoid region extending to the left auricle for about an inch. There was a complete peripheral left facial paralysis. (Fig. 3.)

A suture of the facial nerve was done eight days after admission, May 20, 1931. With a curved mastoid incision the distal end of the facial nerve was found, isolated and traced towards the region of the stylomastoid foramen. About one-quarter inch from the stylomastoid foramen, which was identified

FIG. 3.—(Case II.) Facial paralysis of the peripheral region due to division of the nerve of the stylomastoid foramen.

FIG. 4.—(Case II.) Photograph taken six months after operation showing restoration of facial musculature following suture of facial nerve of stylomastoid foramen.

by a probe, the nerve was found to be completely severed. In order to visualize the proximal end of the nerve, a portion of the mastoid was removed and about one-quarter of an inch of the external wall of the Fallopian tube. The nerve ends were then approximated without tension and were sutured with perineural sutures of Carrel silk, three in number. In order to adequately cover the nerve which was exposed in the Fallopian canal, a free fat transplant about two inches in diameter was taken from the anterior abdominal wall and placed in the cavity. The skin was sutured over this.

Six days after operation physiotherapy was started, consisting of radiant light to the left face for one week, one hour daily. The wound was clean and the sutures removed on the ninth day, and the patient was discharged June 9, 1931, to the physiotherapy department for treatment. She reported there for a week and was then lost sight of until October 30, 1931. Examination then disclosed definite improvement in all the movements of the left facial musculature. The droop at the corner of the mouth was not quite so

marked and she was able to close her left eye quite well. She was seen November 17, 1931, by Doctor Blakeslee, the neurologist, who felt that she almost had complete return of power and that further physiotherapy was unnecessary. (Fig. 4.)

Dr. Byron Stookey said that it seldom fell to the lot of the nerve surgeon to do an immediate end-to-end repair of the facial nerve since repair is usually done by the general surgeon operating for a parotid tumor. While Doctor Colp has done an end-to-end suture with excellent results, it is interesting to note that in spite of end-to-end suture the ability to wrinkle the forehead has not returned, whereas contraction of the lower half of the facial innervation has returned.

There is also a loss of spontaneous emotional control of the face in spite of the return of innervation of the lower half of the facial musculature. Volitional contraction of the frontalis and emotional control of the facial muscles are precisely the two factors which are likely to be lost after nerve crossing either facial-spinal accessory or facial-hypoglossal. The absence of these two factors is to be expected after nerve crossing but not after direct nerve suture, since after nerve crossing new and different nuclear centres with different reflex afferent and efferent connections are connected with the peripheral structures, and thus old reflex connections are lost, whereas by direct nerve suture the old nuclear connections are made and old reflex connections reëstablished.

KRUKENBERG AMPUTATION

Dr. Ralph Colp presented a boy, twelve years of age, who was admitted to the Beekman Street Hospital October 27, 1930.

On the day of admission, he had held an ignited torpedo in his hand which exploded. He was immediately brought to the hospital. Examination disclosed a maceration and avulsion of the entire right hand up to and including the wrist-joint, so that no bones were spared in the destruction. There were also powder wounds which extended through the skin into the soft parts over the lateral aspect of the arm on the same side to the mid-brachial region. Amputation of the right hand and wrist was done through the carpo-radial articulation. The periosteum of the radius and ulna was not disturbed. The skin was trimmed for a considerable distance and the parts remaining looked very clean. The whole area was thoroughly irrigated with saline and a few chromic sutures approximated the muscle and fascial elements over the ends of the bone, the skin being closed with a few silk sutures. At the same time, a débridement was also done on the powder marks of the arm. Two pieces of iodoform gauze were inserted into the defects of the arm and the wound dressed dry.

There was considerable sloughing following the procedure, but under Dakinization the stump was clean enough for a Thiersch graft on November 21, 1930. This was subsequently supplemented by pinch grafts. The forearm was ready for a Krukenberg plastic January 21, 1931. A brief résumé of the technic is herewith given:

(1) A U-shaped incision is made from the volar to the dorsal aspect of the forearm slightly to the ulna side, and over the attachment of the interosseous ligament to the ulna.

(2) The dorsal incision is deepened to the extensor muscles. The extensor communis digitorum is identified and the tendons to the second and third finger are sutured together. The tendons to the fourth and fifth fingers are similarly sutured. The extensor carpi ulnaris is left on the ulnar side. The brachio radialis and both extensor carpi radialis muscles are attached to the radius. The abductor pollicis longus, the extensor pollicis longus and brevis are excised.

(3) The volar incision is now deepened to the flexor muscles. The flexor carpi ulnaris and radialis are left on their respective sides. The divisions of flexor sublimis digitorum are treated similar to the extensor communis digitorum. The flexor profundus digitorum and the flexor longus pollicis are extirpated.

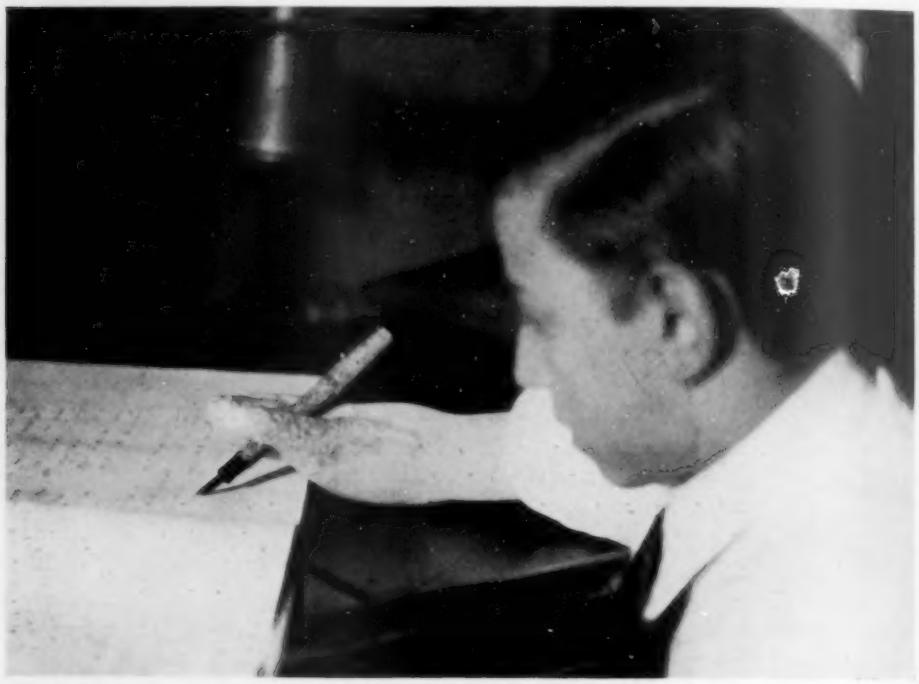

FIG. 5.—(Case III.) Showing grasping power with Krukenberg stump.

(4) The median and ulnar nerves are identified and adequately resected and the stumps injected with alcohol.

(5) The interosseous membrane is then slit *throughout* its length and removed so that the radius and ulna are then separated for about twelve centimetres of their extent, and the distal extremity of the ulnar and radius excised.

(6) The flexor and extensor tendons are then stutured together over the radius and ulna respectively.

(7) The radial stump as a rule may be covered with the overlying skin which is present.

(8) It is very seldom, however, that there is sufficient integument to cover the ulna stump. It is usually advisable to do a pedicle skin graft to this stump from the side of the abdomen. This is best performed by making a skin flap and suturing it to the skin left on the ulna. The stump is immo-

bilized to the abdominal wall for ten to twelve days. The skin flap is then freed from the abdomen and the closure completed.

January 28, 1931, the wound was dressed. The skin flap around the stump of the radius had sloughed while the pedicle flap to the ulna was viable.

February 11, under general anæsthesia, the pedicle to the graft was divided and sutured about the ulna, although part of it remained uncovered.

February 25, under anæsthesia, pinch grafts were taken from the right anterior femoral region and placed on the granulating area over the radius and parts of the ulna and paresine dressing applied.

March 4, 1931, the boy had amazing grasping power of the stump. (Fig. 5.) The ulna was practically healed and about 30 per cent. of the pinch grafts of the radius had taken.

The patient was discharged March 11, 1931, at which time the stumps

Fig. 6.—(Case III.) Showing case of Krukenberg operation of radial stump in pronation.

had practically healed. There was complete extension at the elbow (Fig. 6) and the patient had good grasping power of the stumps. Since that time, patient has been seen on many occasions. He has complete flexion and extension of the elbow; pronation and supination of the radius about the ulna is complete, although abduction and adduction of the radial stump is practically negligible.

This case demonstrates a simple method first described by Krukenberg in 1917 of converting a forearm without a hand into a grasping sensitive mobile extremity. It is certainly superior to any artificial hand or a complicated kinoplastic amputation.

There is no doubt that the cosmetic effect is poor but an artificial hand may be fitted which may prove useful because of the mobility of the hand transmitted through the mobile radial stump, or a special working prosthesis may be worn which will permit the individual to actually perform heavy manual labor.

SUBSTERNAL GOITRE WITH ACUTE DYSPNŒA. BRONCHOSCOPY AND SUBTOTAL THYROIDECTOMY

DR. RALPH COLP presented a woman, forty-five years of age, from the surgical service of Dr. Richard Lewisohn at Mount Sinai Hospital. Past history was irrelevant and there were no symptoms of preëxisting goitre, either simple or toxic.

For the past year, the patient had been aware of an increasing fullness at the base of the neck, but she was never aware of a definite mass in this location. In the week prior to admission, she had three attacks of marked dyspnœa, cyanosis and loss of consciousness. The first attack occurred four days ago, the second, two, and the third on the day of admission. Each episode started with a choking sensation and dyspnœa. The inspiration and expiration became stridulous in character, and increasingly difficult. Each attack lasted for an hour and finally terminated with the expectoration of phlegm.

She was an obese, short, middle-aged woman sitting upright in bed, extremely dyspnœic, with marked inspiratory stridor. She was cyanotic. The pulse was 90, respirations 30, and temperature 99.8°. Examination disclosed a hard, firm, diffuse enlargement of the thyroid, slightly more marked on the left, extending suprasternally about two inches. This mass disappeared substernally. X-ray examination of the chest showed a marked enlargement of the thyroid gland which extended into the chest about two centimetres below the aortic arch. The intrathoracic portion of the trachea was displaced to the right. There was a hypertrophy of the left ventricle with some dilatation.

In view of the impending asphyxia caused by the compression and a deviation of the trachea, operation was performed immediately. A seven-millimetre bronchoscope was passed under local anæsthesia of cocaine. At about twenty-five centimetres the trachea was compressed to three millimetres. The stridor immediately disappeared with the dilatation of the trachea and the cyanosis cleared as soon as the oxygen was administered through the tube. Under novocaine anæsthesia, a transverse Kocher incision was made suprasternally. The ribbon muscles were divided transversely. The upper pole of the right lobe of the thyroid was ligated and divided, and by traction and digital manipulation, the substernal portion of the right lobe was delivered. The lobe was excised in its major portion together with the isthmus. The same procedure was performed on the intrathoracic left lobe. The pathology of the gland was a colloid goitre with fibrous and chronic inflammation. The trachea was now completely exposed and the bronchoscope was withdrawn. There was no subsequent collapse of the trachea and there was no recurrence of the dyspnœa. The ribbon muscles were reunited by mattress sutures. The substernal space was packed with iodoform gauze and the wound was closed with pincets. Following this operation, she did well, although she developed a small patch of bronchopneumonia in the left lower lobe. She was discharged on the tenth post-operative day.

The passage of a bronchoscope in the intrathoracic type of goitre with tracheal compression and deviation certainly relieves the dyspnœa and simplifies the operative procedure. A definite air way is maintained, the danger of immediate tracheal collapse is obviated and the trachea can be identified in the operative field without difficulty by the presence of the metal cylinder. The bronchoscope is preferable to a whale-bone catheter in that the metal tube is passed under direct vision, the tracheal air way can be kept free from mucus by suction, and oxygen can be administered, if necessary. This patient was not particularly uncomfortable with the bronchoscope in place during

the operative manipulation. At the conclusion of the thyroidectomy, the tube was slowly withdrawn and the calibre of the trachea observed. If a collapse would have occurred, tracheotomy could have been performed immediately. This, however, was not necessary.

DECOMPRESSIVE LAMINECTOMY FOR FRACTURE OF THE SIXTH CERVICAL VERTEBRA WITH ALMOST COMPLETE QUADRIPLEGIA

Dr. DeWitt Stetten presented a man, aged thirty-five years, who was admitted to the Lenox Hill Hospital December 22, 1931, with the history that on the previous afternoon he had been struck on the back of the neck by some blunt object, possibly a blackjack. He became unconscious, and, on regaining consciousness, could move neither his arms nor his legs; his legs were numb, he had pain in the back of his neck, and he was unable to urinate. He was a fairly well-nourished and well-developed individual. There was some ecchymosis of the left lower eyelid and of the left malar region. There was some spasm and rigidity of the posterior cervical muscles, and in the region corresponding to the sixth cervical vertebra there was definite bony crepitation on manipulation of the sixth spinous process. There were no excursions of the chest-wall, respirations being entirely diaphragmatic. There existed almost a complete flaccid paralysis of all the extensors of both upper extremities, of the muscles of both hands, and of both lower extremities, with spastic contraction of the flexors of the forearms and hands, the patient holding both forearms flexed on the chest in the characteristic Erb position. The spasticity of the flexors of the upper extremities was perhaps a little more marked on the right than on the left side. He could move both great toes slightly, particularly the left, which he could extend and flex a trifle. The right could only be feebly flexed. The abdominal and right cremasteric reflexes were absent; the left cremasteric was very sluggish. The biceps, triceps, patellar, suprapatellar and Achilles reflexes were all equal and active. There was no Babinski or Oppenheim, but on irritating the soles the patient exhibited marked mass reflex or spinal automatism with gross muscular contractions of both upper and lower extremities. There was moderate anæsthesia to pain, tactile and temperature sense on the inner aspects of the hands, forearms and arms, and from a hand's breadth above the level of the nipple downward. The sense of position in the lower extremities was also disturbed. There was no dissociation of sensation. The neurological picture definitely indicated an involvement of the lower cervical (C VII, C VIII) and upper thoracic (D I) segments of the cord. Bedside X-ray examination revealed no recognizable fracture or dislocation in the cervical spine. The spinous process of the sixth cervical, however, was slightly out of alignment, being displaced a trifle to the right, and there was a definite torticollis with the head turned to the left, and some elevation of the left shoulder. Rectal examination showed marked relaxation of the sphincter ani.

Before admission to the hospital, he had been catheterized, and, apparently, the urethra and bladder had been infected, because a definite purulent urethral discharge was noted immediately on admission. It was decided to continue catheterization with the usual disinfection of the bladder, and not to attempt emptying the bladder by expression. There was complete rectal incontinence. Two days after admission the feeble great toe movements on both sides disappeared. The Queckenstedt manœuvre showed no spinal block. The spinal fluid was clear and showed twenty-five lymphocytes to the cubic millimetre.

Five days after admission the patient had apparently deteriorated as indicated by lost toe movements. The outlook for the conservative treatment was very grave. December 28, 1931, operation was performed by Doctor

Stetten under local anæsthesia with the patient in the prone position. A long, longitudinal, median incision over the lower cervical and upper thoracic spine was made. As soon as the spines were exposed, distinctly greater mobility of the spinous process of the sixth cervical vertebra and definite crepitation on motion were noted. There was an irregular oblique line of fracture through both laminæ of the sixth cervical vertebra, on the right side about 1½ centimetres from the spine, and on the left side about 1¼ centimetres from the spine. The lines of fracture ran from above downward and from within outward. There was a definite, though slight, depression of the fractured

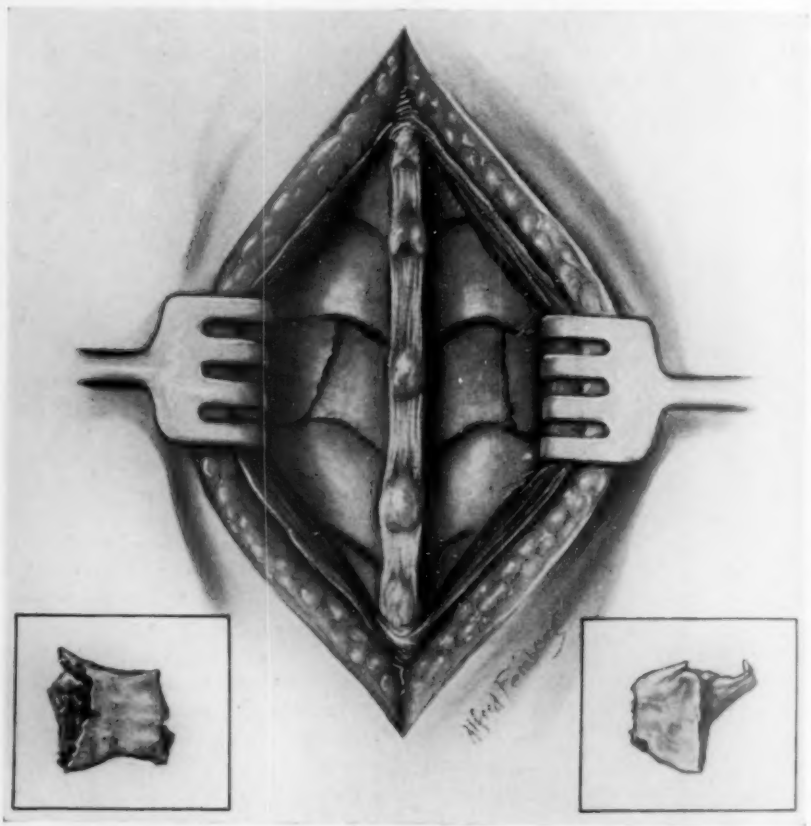

FIG. 7.—Drawing showing lines of fracture in both laminæ of the sixth cervical vertebra and slight depression of the laminar arch as found at operation. Inserts show the appearance of the fragments of the laminæ when removed. Note curved spicule on upper edge of the fractured end of the right fragment.

arch and some extravasation of blood around the fracture lines. The spinous processes and arches of the fifth and seventh cervical vertebræ were thoroughly exposed and found to be uninjured. After removing the spinous process of the sixth cervical vertebra with the rongeur, the loose fragments of both laminæ were extracted without difficulty, first from the right and then from the left side. At the upper edge of the fractured end of the right fragment was a definite, curved spicule of bone about three-quarters of a centimetre long, which apparently had further pressed on the cord. (Fig. 7.) The cord surrounded by its dura filled the canal rather tensely. The dura was œdematous and slightly ecchymotic. It was decided not to open the dura for fear of a herniation of the cord. The sharp lateral edges of the fractured

laminæ were rounded off with a rongeur. A moderate amount of bleeding was encountered on doing this, especially on the right side, but this was easily controlled by two gauze tampons to the right lateral stump. These were led out through the central portion of the wound, which was sutured in the usual manner.

The patient made a satisfactory recovery from the operation, although two days later his temperature rose to 102.6° and his urine became more and more cloudy, in spite of bladder irrigations with boric-acid solution, and instillation of collene and urotropin internally. An indwelling catheter was inserted. Three days after operation there was noted for the first time a definite return of some power in the lower extremities. The patient was able to flex and extend the toes of the left foot, particularly the great toe, with visible muscular contractions of the leg. This rapidly increased and within another twenty-four hours some return of power was noted in the paralyzed muscles of the left hand, arm and forearm. Three days later there was beginning power noted in the right lower extremity. By January 9, 1932, sensation was rapidly recovering, and passive and active motion of the arms and legs, and massage, to which was subsequently added Faradism, were begun. Steady improvement in all four extremities continued with relaxation of the spasm of the right biceps. There was likewise improvement in the movements of the thoracic muscles in breathing. The wound had healed by primary union.

In spite of this, however, the patient did not seem to be progressing favorably. There was considerable loss of weight and marked atrophy of all the musculature, indicating medullary or anterior horn involvement. He had evening rises of temperature as high as 103°. The urine was very purulent and showed *Bacillus coli, Staphylococcus albus* and *Bacillus subtilus* on culture. There was no evidence of involvement of the kidney. As it was apparent that the infection of the lower urinary tract was threatening the patient's life in spite of the favorable progress of the spinal condition, it was decided, as a last resort, to drain the bladder suprapubically. January 22, 1932, a suprapubic cystostomy was done by Doctor Stetten in the usual manner, the Kader technic being used. Following this, bladder irrigations through the suprapubic drainage tube were instituted. By February 13, 1932, a definite improvement in the patient's general condition had begun. Motion in all the extremities was much better, and the chest movements on breathing were very good. Sensation had practically returned to normal.

February 23, 1932, the patient began to show fair control of the sphincter ani and rectal examination showed considerable tone of the muscle. Since February 25, 1932, his temperatures have remained normal. The suprapubic drainage tube was removed February 29, 1932, and the patient was allowed up in a chair. Within a few days he began to pass some urine through the urethra. The amounts of urine gradually increased, and by April 20, 1932, the suprapubic fistula was completely closed. The patient began definitely to gain weight, his last weight being only ten pounds below his normal weight before the accident. His atrophied muscles also gained in volume. March 28, 1932, he was walking with help and from April 13, 1932, he was walking without help but using a cane. Since April 16, 1932, he has been walking without a cane, although his gait has been somewhat spastic and uncertain but is improving from day to day. There is a definite drop-foot on the right side due to weakness in extension of the ankle. The extension in the right great toe has not yet recovered and the return of function of the right triceps

has been very sluggish, although the patient is now beginning to extend his forearm a little when it is held in a horizontal plane. The superficial reflexes have all recovered and all the deep reflexes are exaggerated with ankle and suprapatellar clonus. There is a left Babinski. The patient has acquired very fair control of his bladder, although there is some urgency, and he has good control of his rectum.

The case was presented with the realization that the operative treatment of this case is not quite in accord with the teaching of most neurologists and neuro-surgeons in this country. The fact is that here was a case that was definitely deteriorating, where an extremely grave prognosis was given by all the neurologists who examined him, and where, as a forlorn hope, operative intervention was finally decided upon, and followed by almost immediate improvement. It is believed that in this case there was a spinal concussion with an œdema and possibly a hæmorrhage of the spinal cord, and that there existed a definite compression of the swollen cord by the slightly depressed laminar arch, added to by the spicule of bone from the right lamina. The removal of the arch, even without opening the dura, relieved the pressure and permitted an absorption of the œdema and the possible hæmorrhage. Foerster, of Breslau, advocates operation in all of these cases as soon as the spinal shock has subsided. As a matter of fact, there is really no alternative. The operation is an extremely simple procedure, without any element of seriousness, and can easily be performed under local anæsthesia. Another feature worthy of attention is the apparent value of the suprapubic drainage of the infected bladder, which, in this case, threatened to nullify the success of the laminectomy. If the bladder is already infected before the Credé method of emptying it can be instituted, a suprapubic cystostomy may prove a life-saving procedure, as it seems to have done in this case.

Dr. Byron Stookey said that the essential problem in fracture dislocation of the cervical vertebræ is reduction of the displacement with relief of the pressure of the displaced vertebræ upon the spinal cord. It was his opinion that by far the most satisfactory procedure is reduction by traction and application of suitable measures to maintain the reduction rather than by open operation and immediate fusion of the vertebræ.

With forward displacement of the bodies of the vertebræ reduction of the vertebral displacement by operation seldom can be accomplished. By laminectomy the arches of the vertebræ are removed and the stability of the bony structure weakened without reduction of the displaced bodies. In early cases traction without operation usually permits satisfactory reduction of the displaced vertebræ and relief of pressure upon the spinal cord can usually be accomplished. In late cases reduction by traction frequently cannot be done.

Neither by traction nor by operation can the damage already done to the spinal cord by hæmorrhage within the spinal cord be altered. However, by reduction of the displaced vertebræ and the coincident realignment of the spinal cord into its normal position within the vertebral canal, the cord is placed in a more favorable position than when the vertebral displacement is not reduced and only a decompressive laminectomy is done. In the latter instance the dorsal alignment of the vertebral canal is straightened; the ventral angulation remains and the sharp edge of the displaced vertebræ persists, whereas by traction and reduction without operation the contour of the dorsal

and ventral parts of the vertebral canal can usually be restored if traction can be made early.

This patient apparently had a simple fracture of the lamina without displacement of the vertebral bodies with comparatively little or no compression of the cord. The manometric test of the spinal cord shows no block and the fluid was clear, which is excellent evidence of the freedom of the spinal subarachnoid space from serious pressure.

One gathers that the greatest disturbance was the hæmorrhage into the spinal cord with resulting cord signs and spasticity. This hæmorrhage into the cord was the result of the blow and not due to prolonged pressure on the cord. Simple fracture of the lamina which no doubt existed could have been corrected, in Doctor Stookey's opinion, by simple traction and immobilizations. Laminectomy did not alter the situation as far as the hæmorrhage within the cord is concerned and Doctor Stetten very wisely did not open the dura of the spinal cord in view of the signs which he already had found.

Hematomyelia usually shows recession and consequent improvement in the signs, which, of course, laminectomy does not alter. Doctor Stookey's opinion was that as a rule traction is far superior to laminectomy and that in this instance simple traction and immobilization were preferable to operation.

Dr. Clay Ray Murray emphasized the amount of relief secured by traction in extension of the spine in these cases. He thought that in the presence of direct bony pressure on the cord, or even when the symptoms were due to hæmorrhage and œdema, under proper traction and extension those symptoms would clear up in the vast majority of cases with as much efficacy as operation could offer, without any of the risks of operation. Laminectomy in his opinion does not present the chances of recovery which may be present under more conservative types of treatment. He reserves it for those cases which under hourly observation either fail to show any relief under traction-extension of the spine, or actually retrogress, and for those cases in which improvement occurs for a while but then ceases short of a point representing a satisfactory cord function.

Doctor Stetten reported that the spinal fluid was not bloody, and there was no evidence of block. In spite of these facts, however, Dr. Foster Kennedy strongly urged him to operate on this man, because Doctor Kennedy felt that otherwise the prognosis was utterly hopeless. Doctor Stetten realized that surgical intervention in these cases is not looked upon with great favor in this country, but felt that the successful result in this case was worth reporting. He also appreciated that one cannot say that this patient would not have recovered without operation, but the fact remains that he made an unusual recovery after operation, and it is possible he may not have done so without.

CHRONIC SUPPURATIVE PERINEPHRITIS

Dr. DeWitt Stetten presented a girl, aged fifteen years, who was admitted to the Children's Division of the Lenox Hill Hospital November 30, 1931, under the care of Dr. Jerome S. Leopold. For two and one-half years the patient had been complaining of obscure right-sided abdominal pain, had become progressively weaker, had not grown nor matured normally, and had developed a gradually increasing pallor. Recently she had acquired a limp with favoring of the right leg, and about two years previously a rather marked scoliosis to the left had formed. About three years before admission she had had several large furuncles on the right buttock. A few months later, on June 29, 1929, she was admitted to the Fifth Avenue Hospital, complaining of pain in the right upper quadrant of about ten days' duration. A diagnosis of a laterocecal appendix with abscess or a perinephritic abscess was made and the patient was operated on July 5, 1929. An appendicectomy was done through a right Kammerer incision. An inflamed laterocecal appendix was found but no pus. The kidney region was carefully examined but there was no evidence of a perinephritic abscess, although there was some inflammatory œdema of the peritoneum over the lower portion of the kidney.

The patient's convalescence was rather stormy and for some time after operation she suffered from indefinite abdominal pains. She did not improve but continued to lose weight and began to limp, favoring the right leg. On admission to the Lenox Hill Hospital she presented the picture of an underdeveloped, emaciated child with drawn facies and marked pallor. She had a pronounced dorsolumbar scoliosis with lumbar convexity to the left. There appeared to be some spasm over the right lumbar region, but no bulging, tenderness or fluctuation. Murphy's sign was negative. The abdomen was scaphoid. In the right upper quadrant could be felt a definite firm, fixed mass, corresponding to the lower right kidney region which was slightly tender on deep pressure. In the left upper quadrant could be felt a smooth, firm mass, which moved on respiration to below the umbilicus, and which was undoubtedly a large kidney. X-ray examination showed a marked left lumbar scoliosis, almost complete obliteration of the right psoas margin, a very large left kidney, and no definite right kidney shadow. Skiodan injection revealed normal function and outlines, left, and much impaired function, right. On cystoscopy the bladder was normal and catheters could be passed up both ureters. The indigo-carmine test showed marked loss of function of the right kidney and a pyelogram, right, showed distinct clubbing deformity of the calices.

The temperature during the period of observation from November 30 to December 21, 1931, fluctuated irregularly between 98.2° and 102.8°. The blood showed a severe secondary anæmia with a moderate leucocytosis. Blood and urine cultures were sterile. The urine was practically normal. The von Pirquet test was negative.

After a preliminary transfusion she was operated on by Doctor Stetten under general anæsthesia December 21, 1931. Through an oblique right lumbar incision, the perirenal space was entered and found to be a mass of dense, infiltrated, œdematous fat, in which were areas of yellowish, cheesy, necrotic, semi-solid material, obviously old inspissated pus, and in places a franker, fresher, and more fluid purulent exudate. This was particularly marked around the upper pole of the kidney. A culture was taken and the infiltrated perirenal tissue was incised down to and through the thickened kidney capsule, and the kidney was decapsulated. The kidney itself was

relatively normal. The culture of the pus showed a pure *Staphylococcus aureus*. The patient's convalescence was relatively uneventful. She was afebrile on the fourth day after operation and steadily improved from that time on. Drainage was maintained as long as possible. Her blood-picture assisted by several transfusions rapidly improved and she steadily gained weight and strength. Her limp and scoliosis gradually disappeared. She was discharged from the hospital February 14, 1932, with the wound entirely closed. March 17, 1932, she menstruated for the first time. Her weight at the present time is 107 pounds, a gain of thirty-nine pounds since just before her operation, and her blood-picture is practically normal.

Dr. Donald Gordon said that in the presentation of this case he was the surgeon who operated upon the patient for appendicitis at the Fifth Avenue Hospital.

At operation, the mesocolon had to be incised to release the appendix. A degree of œdema was appreciable at the lower pole of the kidney. The peritoneum was opened to a small extent, and the lower pole of the kidney palpated without revealing sufficient pathology to warrant further exploration for pus, in view of the position and appearance of the appendix. After three months the patient had gained nine pounds, but subsequently in a two-year follow-up period, made no progress; but there was no mention of a limp being present, though she unquestionably was not a well child. The persistence of symptoms in the hospital and after discharge were never explained until Doctor Stetten's information about the case.

Dr. Abraham Hyman called attention to the long period of time, two years, which elapsed before the kidney condition was recognized. This was longer than usual although there have been a number of cases where one to one and one-half years have elapsed before diagnosis was made. Even in the late stages of the condition the diagnosis has been frequently overlooked or mistaken for gall-bladder or appendicular disease. This is due chiefly to their being so few symptoms referable to the kidney. The course is likely to be afebrile, although there may be a low-grade temperature. Urinary examination may be entirely negative and cystoscopy throw no light on the situation. The most important diagnostic findings are the radiographical signs; these in a large percentage of cases enable one to differentiate the condition. The typical radiographical changes are enlargement of the renal shadow, obliteration or haziness of the outline of the psoas muscle, and a scoliosis of the spine with concavity towards the affected side. In addition, there are almost always suggestive pyelographical changes, evidenced by distortion or filling defects of the pelvis or calices. In the early cases all of these signs may be ill-defined, not being suggestive enough to establish a diagnosis. In such conditions, at the suggestion of Doctor Beer, at Mount Sinai Hospital, they activate the focus by the injection of staphylococcus vaccines, and have by this process been enabled in a few instances to locate the lesion. Following injections of the vaccine, where the temperature has previously been normal or at a low level, a positive reaction is evidenced by a

rise of temperature with pain and tenderness to percussion in the affected kidney. Practically all of these cases do well with a simple decapsulation and drainage. In only a few instances has it been found necessary to do a secondary nephrectomy.

SPLENECTOMY FOR CHRONIC THROMBOCYTOPENIC PURPURA

Dr. DeWitt Stetten presented a woman, aged forty-five years, who gave a history of profuse menstrual periods of a twenty-eight-day type, lasting six or seven days, and dating from the onset of her menses at the age of twelve years. About eight years before admission she had had a period which lasted ten days and was unusually profuse, assuming the character of a real hæmorrhage. Five years later she had a similar episode. About six weeks before admission she had a menstrual period with very severe bleeding which lasted ten days. The bleeding stopped, but recurred with her present period about four days before admission, when she again bled very profusely and continuously. This profuse bleeding persisted and she developed profound general weakness, marked pallor, and dizziness. The patient had never been pregnant, and there had been no uterine bleeding between her menstrual periods. She had had occasional epistaxis and bleeding from the gums. Ever since childhood she would easily develop purpuric spots after slight injury. She had never had any intestinal bleeding. She weighed 125 pounds. Her skin showed several scattered purpuric spots, and several small subconjunctival petechiæ on the lower eyelids. In both nares there were several dried blood-clots. In the mucous membrane of the mouth were several fresh petechiæ over the uvula and soft palate. The veins in the neck pulsated markedly, but there were no palpable lymph-nodes. There was a short blowing systolic murmur in the left second interspace. The liver edge was just palpable, and the spleen was enlarged to four fingers below the costal margin along the anterior axillary line. In the lower abdomen was a large, irregular, hard, nodular mass, obviously a fibromyomatous uterus, reaching from the symphysis to two inches above the umbilicus, and laterally three inches to each side of the mid-line. Vaginal examination showed the bulging of the posterior fornix due to an irregular, hard, nodular mass, which pushed the cervix up against the symphysis. This mass was continuous with the large fibromyomatous uterus, which was felt on abdominal palpation. It was firmly impacted in the pelvis. A transfusion of 600 cubic centimetres of blood was given December 6, 1930, followed by four deep X-ray treatments to the pelvis from December 10 to 13, 1930, inclusive. Following the X-ray treatments the bleeding diminished somewhat, but a careful hæmatological study by Dr. M. A. Weiss December 7, 1930, showed a very severe secondary anæmia, 3,410,000 erythrocytes with 47 per cent. hæmoglobin; a moderate leucopenia, 4,600 leucocytes with a normal differential count; a prolonged bleeding time of twenty-four minutes; a normal coagulation time of four minutes; delayed clot retraction; and marked reduction in the blood platelets to 10,500.

The diagnosis of thrombocytopenic purpura, probably of the reticuloendothelial or thrombolytic type, was now rather clearly established, throwing somewhat into the background the importance of the uterine problem. The patient was treated for four weeks on the medical service of Dr. M. A. Rothschild at the Beth Israel Hospital. Her menstrual bleeding continued most of that time, and she also suffered from nose-bleed. Her platelets

ranged from the initial count of 10,500 to 39,500, her anæmia remaining about the same, and her leucocyte count ranging from 4,400 to 9,600 with comparatively normal differential figures. She was finally transferred to Doctor Stetten's service and January 8, 1931, after a second transfusion of 500 cubic centimetres of blood, a splenectomy was done by him. The spleen was about twice its normal size, fairly firm and very elastic. There were fine adhesions between its outer surface and the vault of the diaphragm, but these were separated without difficulty, and the removal of the organ, after the usual ligation of the pedicle, was quite simple. The microscopical examination of the spleen was essentially negative.

Convalescence was relatively uneventful, and the wound healed by primary union. Immediately after operation the platelets jumped to 196,000, running up as high as 296,000. There was also a leucocytosis running up to 30,400 immediately after operation, and remaining around 10,000. The menstrual bleeding ceased immediately and did not recur. The patient's general condition also improved, her hæmoglobin going up to about 60 per cent. with 4,000,000 erythrocytes. About January 17, 1931, a rather marked dermatitis developed over the X-rayed area. The patient's progress was so satisfactory that February 14, 1931, under spinal anæsthesia, Doctor Stetten performed a supravaginal hysterectomy with double salpingo-oöphorectomy. A very large, irregular, nodular uterus, the size of a seven months' pregnancy, containing various sized and shaped subserous, intramural and submucous fibromyomata, was removed, with both tubes and ovaries. A partially obliterated appendix was also removed.

The patient made a very satisfactory recovery from this second operation, but around March 10, 1931, she developed some induration in the lower angle of the wound with a slight rise of temperature. This induration, probably a sequel of the X-radiation, formed into an abscess, which March 13, 1931, was opened and several ounces of thick, yellow, odorless pus were evacuated. From then on the patient's convalescence was quite satisfactory except that the abscess cavity healed very sluggishly. Since the wound has been healed, the patient has been steadily improving and is now in perfect health. Her weight now is 153 pounds, a gain of twenty-eight pounds since just before her splenectomy, and her blood shows a very interesting picture. She now has a marked polycythæmia with 7,090,000 erythrocytes, and 90 per cent. hæmoglobin, a definite leucocytosis of 17,800 with 50 per cent. polymorphonuclears, 39 per cent. lymphocytes, 8 per cent. monocytes, and 1 per cent. each of basophiles, metamyelocytes and premyelocytes. The platelets have remained at 295,000. What undoubtedly brought about a successful result in this case was the preliminary splenectomy.

DR. ALLEN O. WHIPPLE said that he had a similar case in the Presbyterian Hospital. The patient, a woman, was referred to the Thyroid Clinic because of a mass, increasing in size, in the left side of the neck, said to be an adenoma of the thyroid. Because of the possibility that the adenoma might continue to increase in size and give her cardiac symptoms, she came to the hospital for operation. In the course of questioning she gave a history of bruising easily and of occasional nose-bleeding. She had prolonged clotting and bleeding time and the platelets were reduced in number. An incision ½ centimetre in length was made in the neck but bleeding continued for twenty-four hours and for that reason it was decided that splenectomy was

indicated. She went through this operation exceedingly well and is now convalescing.

Dr. Edwin Beer said that in regard to the excellent results supposed to follow splenectomy, he wished to refer to a case of thrombocytopenic purpura in which bleeding did not cease, following splenectomy, until the pituitary was exposed to deep X-ray therapy.

Fig. 8.—Radiograph of hand before first operation, showing various amputations.

PLASTIC RECONSTRUCTION OF HAND WITH PHALANGEALIZATION OF THUMB

Dr. DeWitt Stetten presented a man, aged nineteen years, who October 3, 1930, severely crushed his left hand. He was taken at once to the Bronx Hospital, where in spite of conservative treatment, the entire index finger, distal phalanx of the thumb, and second and third phalanges of the middle, ring and little fingers were lost, and the skin of the palm and dorsum was also completely destroyed, all through the development of gangrene. October

24, 1930, he was admitted to the Lenox Hill Hospital, under Doctor Stetten's care. At that time the left hand was completely devoid of skin from the wrist downward, and was covered by a fairly clean, rather flat, granulating surface. The index finger was missing. The thumb and middle fingers had been amputated through the middle of the proximal phalanges, and the ring and little fingers had been amputated through the distal fourths of the proximal phalanges. As there was no skin between the stumps of the thumb and the index metacarpal, and between the stumps of the middle, ring and little fingers, there was a tendency for the interdigital spaces to become obliterated. Wrist motion, both flexion and extension, was somewhat restricted, as was supination and pronation. X-ray examination (Fig. 8) simply confirmed the findings of the various amputations, which appeared to be fairly clean cut. No fractures nor disease in the remaining bones of the hand was revealed.

A plastic reconstruction of the hand was undertaken. Under appropriate dressings the granulations still further improved and some islands of epi-

FIG. 9A.—Photograph of hand before operation, palmar aspect.

FIG. 9B.—Photograph of hand before operation, dorsal aspect.

thelium formed, particularly over the thenar and hypothenar eminences of the palm. These islands gradually fused, covering these areas to a large extent. From the thenar eminences the epithelium extended around somewhat on the radial side. A small amount of the same kind of epithelium formed in the webbing between the thumb and head of the index metacarpal. The dorsum showed practically no epithelial islands. (Figs. 9A and 9B.)

The first operation was performed November 10, 1930. A pocket of skin was prepared on the right side of the chest on a level with and close to the nipple, the width of the flap being wide enough to cover the hand comfortably. The full thickness of skin was undermined and separated from the chest wall, leaving the flap attached by broad pedicles above and below. The islands of epithelium were removed from the radial side and from the webbing between the stump of the thumb and head of the index metacarpal, the epithelial patches on the palm being retained. The edge of the skin on the dorsal side of the wrist was freed for about a quarter of an inch upward and the edge it-

self freshened. A piece of rubber dam was laid into the floor of the pocket across the chest, completely covering same. The edges of this were drawn through anteriorly and posteriorly and sutured to the skin to hold it in place. The left hand was comfortably placed into this subcutaneous pocket and the skin on the anterior edge of the flap was sutured to the skin of the dorsum of the wrist. A dry dressing was applied, and the hand and arm were immobilized in a starch bandage.

The wound between the dorsum of the wrist and the anterior edge of the flap healed by primary union, and the flap itself promptly became adherent to the dorsum of the hand. December 4, 1930, the second stage was done. The upper pedicle was divided a moderate distance above the hand, but still well below the axillary hair. The pedicle was loosened from the chest wall and some of the thin epithelium from the thenar eminence was removed. The skin on the radial side of the anterior surface of the wrist was freed and the edges freshened. The flap was rolled around the thumb and the tips of the fingers, and sutured without tension to the hand, the suture line at the wrist being between the anterior edge of the flap and the relatively normal skin on the anterior surface at the radial side and at the thenar eminence between the upper edge of the flap and the new epithelium on the palm. Some pinch grafts were taken from the skin of the anterior surface of the chest and applied to the chest wound, and the anterior upper angle of this wound was partially sutured. The patient also made an uneventful convalescence from the second operation except that the pinch grafts, though they seemed to have taken at the first dressing, apparently absorbed later, and there was a slight retraction of the upper edge of the flap, but there was primary union of the suture between the anterior edge of the flap and the skin at the anterior surface of the radial side of the wrist.

January 17, 1931, the third stage of the operation was performed. Both anterior and posterior incisions of the flap were extended downward, and the flap was freely mobilized from the lower chest and lateral abdominal walls, with the pedicle still broadly attached below. The hand had grown rather firmly to the chest wall, especially at the stump of the little finger, and sharp dissection was required to separate it. The hand was lowered so that the flap rolled around on the palm and all the new epithelium on the palmar surface of the hand, which had formed over the thenar and hypothenar eminences, was removed with knife and curette. Most of the removed epithelium was grafted to the fresh wound area on the lower chest. All the skin edges of that portion of the flap that was adherent to the hand, and of the skin on the anterior surface of the wrist at the ulnar side, were freed and freshened. The free edge of the anterior portion of the flap was sutured to the skin of the anterior surface of the wrist, at the ulnar side, and to the edge of the adherent flap along the stump of the thumb. The posterior free edge of the flap was sutured to the edge of the adherent flap over the tips of the finger stumps and palmar surface of the stump of the middle finger, leaving only a very small area over the thenar eminence and adjacent palm uncovered. There was no tension on the sutures, and the entire enveloping flap seemed very well nourished. A slight flexion contracture of the wrist had developed as a result of the posture, which it was deemed inadvisable to disturb by forcible manipulation at that time. A dry dressing, with an effort to produce a little more extension at the wrist, and a starch bandage, were applied.

There was again a relatively uneventful convalescence with rather satisfactory union of practically all the sutured edges of the flap. Some of the transplanted epithelial grafts had taken in part. February 12, 1931, the fourth

stage of the plastic repair was done, the remaining pedicle of the flap was divided, leaving sufficient flap to cover almost the entire defect on the hand and the hand was separated from the chest wall. The skin edges on the radial side of the hand were freed, and the divided edge of the flap was sutured thereto. The granulations on the tip of the hand stump, on the ulnar side, were curetted and the adherent skin edge at this point freed and freshened, and sutured to the remaining posterior edge of the flap. After thoroughly removing the granulations on the wound of the chest wall right down to the scar tissue, a Thiersch skin-graft was done from the right thigh covering the entire area. Also after curetting the granulations, a small Thiersch skin-graft was made to a small uncovered area over the thenar eminence of the hand. There was a marked flexion contracture of the elbow and of the wrist due to the protracted immobilization. Under anæsthesia the elbow could be extended only with considerable force to about 110°, and the wrist to about 160°. No attempt was made to correct forcibly this contracture. Silver-foil dry dressing was applied to the grafted areas and a palmar splint applied to the hand in as great extension as possible without undue force.

The patient again made an uneventful convalescence, the flap remaining well nourished and the sutured portion healing by primary union. The Thiersch skin-graft on the thenar eminence took about 50 per cent., and even at the first dressing it was noticed that there was a marked degree of acute, almost normal sensation in practically the entire flap, except toward the radial side on the palmar surface and over the stump of the little finger, where there was some anæsthesia. The Thiersch graft on the chest took about 85 per cent. From then on the remaining small granulating areas rapidly healed, and the hand stump was then covered by a rather well-nourished, loose full-thickness graft enveloping it like a mitt with a relatively insignificant scar along the distal extremity of the stump running down the radial side to the thenar eminence. (Fig. 10.) By diligent exercise the patient gradually regained practically normal extension of the elbow, and extension of the wrist to nearly 180°, with flexion of the wrist almost normal. He also acquired fairly good motion in the phalangeal stumps of the ring and little fingers, but there was no motion in the phalangeal stump of the thumb. There was no interference to the elevation of the arm from the chest scar. Sensation also became practically normal except for a small area over the stump of the little finger, where it was somewhat diminished.

FIG. 10.—Photograph of hand after fourth stage of plastic, lateral radial aspect, showing degree of flexion at wrist.

September 25, 1931, the fifth stage of the repair was done by the construction of a radial-dorsal flap made by incising the skin between the metacarpal of the middle and ring fingers, continued through the scar at the distal extremity of the stump. The metacarpal bone of the index finger with the adjacent intrinsic muscles and tendons was excised, a disarticulation being done at the metacarpal-carpal articulation. A similar ulnar-palmar flap was

then formed by continuing the incision through the scar at the end of the stump into the scar at the radial side, the old skin scar being elliptically excised. The flaps were made in this manner so as to have only one line of cicatrix on the thumb stump. The thumb was then bluntly separated from the balance of the hand down to the attachment of the metacarpal bone to the carpus. Both flaps were then incised transversely at their upper edges, the palmar toward the ulnar side and the dorsal toward the radial side, and then swung around and sutured in the typical manner as in the Didot operation for syndactylism, the ulnar-palmar flap to the dorsum of the hand, and the radial-dorsal flap to the palmar surface of the thumb. The former flap could be sutured almost completely without great tension, except at the upper portion. The thumb was also relatively well covered except at the upper portion. The triangular apex of the flap on the tip of the thumb stump was

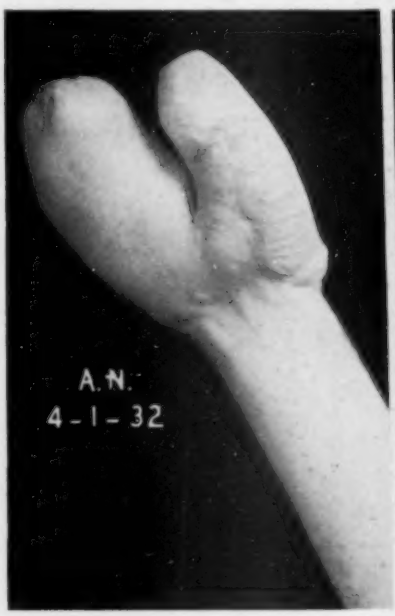

FIG. 11.—Photograph of hand after final plastic and complete healing, palmar aspect.

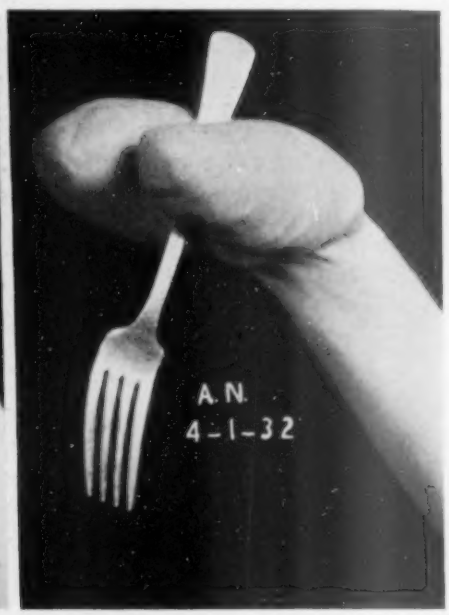

FIG. 12.—Photograph of hand after final plastic and complete healing, lateral radial aspect, showing ability to grasp fork.

fitted in to cover the end of the thumb very satisfactorily. A dry dressing separating the thumb from the balance of the hand and a palmar splint with the wrist in as great extension as possible were applied.

Uneventful convalescence again occurred and the sutured portion of the hand healed by primary union with perfect vitality of both flaps. October 7, 1931, a Thiersch skin-graft from the left thigh was made to the exposed areas on the palmar surface of the thumb stump and on the dorsal surface of the stump of the balance of the hand, and also in the cleft between the thumb and the remainder of the hand, all granulating areas being completely covered. Silver-foil dressing was applied. The skin-graft took 100 per cent.

From then on the wounds remained healed except that several superficial furuncles around the distal extremity of the finger stump of the hand developed. These persisted rather longer than usual, healing very slowly, undoubtedly due to a certain amount of trophic disturbance. When the hand gets cold, the distal extremities of both finger and thumb stumps become bluish-

red and blanch on pressure, the color returning rather sluggishly. The nutrition, however, is gradually improving. The subcutaneous fat has, to a certain extent, atrophied. The motion at the wrist has remained about the same—flexion almost normal and extension to nearly 180°. The patient has been gradually developing the motion in the thumb stump, which he can now adduct and abduct fairly well, and oppose slightly. With the movements in the phalangeal stumps of the middle and ring fingers he has acquired quite some prehensile power, being able to grasp objects—like a fork and pencil,

FIG. 13.—Final radiograph showing absence of index metacarpal with phalangealization of thumb. Also note apparently spontaneous complete disappearance of stump of proximal phalanx of middle finger and partial absorption of proximal phalanges of thumb, ring and little fingers.

or even a sheet of paper or necktie—with comparative ease, and to hold them rather tightly. (Figs. 11 and 12.)

The last X-ray examination shows, of course, the phalangealization of the thumb, and the absence of the greater portion of the metacarpal bone of the index finger. Apparently at the time of the excision of this bone a small wedge-shaped portion at the ulnar side of the base was not removed. This had fused with the radial side of the base of the ring metacarpal and this fusion has formed a clean-cut single articulation with the os magnum and

trapezoid bones of the carpus. The radiograph also shows a general rarefaction due to atrophy of all the bones of the hand, including the lower ends of the radius and ulna. It also shows definite absorption of the stumps of the first phalanx of the thumb, ring and little fingers. They have become not only shorter, more pointed and smoothed off at their distal extremities, but also narrower. They seem to be about one-half their original size. One very unusual feature is that the stump of the first phalanx of the middle finger, which was never disturbed at operation, seems to have completely disappeared by absorption. (Fig. 13.) It is believed that with practice the usefulness of the stump will further increase as the muscular power is developed and the motion, particularly opposition of the thumb stump and extension of the wrist, improves. It is also felt that the subcutaneous fat will still further atrophy, and that this will also add to the utility of the stump. The resection of some of the rather excessive skin at the end of the thumb stump might be considered, and the operative removal of some of the subcutaneous fat might also be done at a future date, if it does not atrophy sufficiently. Further usefulness might also be obtained by a suitable prothesis.

CHOLECYSTECTOMY IN A CASE OF INTRAHEPATIC GALL-BLADDER

Dr. DeWitt Stetten reported the case of a man, aged forty-five years, who gave a typical history of gall-bladder disease dating back to twelve years ago, when he had a characteristic attack of epigastric pain radiating to the right side with vomiting but without jaundice. He had no further attack until seven years later when he again had severe pain, vomiting without jaundice, and rise of temperature to 102.5°. His present attack began about one month before admission to the hospital with pain, which has recurred on and off since. At the beginning of this attack the patient was jaundiced for a short time. On examination there was marked sensitiveness and moderate rigidity just below the right costal margin. The jaundice had disappeared.

Operation at the Lenox Hill Hospital; longitudinal right hypochondriac incision. Rather dense omental adhesions to the upper surface of the right lobe of the liver and some to the under surface of the outer edge of the right lobe. When these adhesions were freed and the edge of the right lobe of the liver thoroughly exposed, no gall-bladder at all could be found, although the duodenohepatic ligament could readily be recognized below what appeared to be the right lobe of a somewhat congested, firm liver. The foramen of Winslow was patent and no calculi could be palpated in what appeared to be the common bile-duct or at the papilla of Vater. The liver (Figs. 14 and 15) was entirely anomalous with a marked lobulation of the lateral portion of the right lobe, which was almost completely divided by means of a deep lateral fissure into a smaller outer and a larger inner portion. At the point that corresponded to the normal bed of the gall-bladder there was another deep fissure between two portions of the medial part of the right lobe which were adherent to each other. A large, somewhat pedunculated quadrate lobe, attached to the liver to the right of the hilus by a rather narrow bridge of liver tissue could be seen protruding below the right lobe, just beneath this latter fissure. Following this fissure backward and palpating the upper surface of the right lobe of the liver where the omentum had been adherent under the diaphragm, a very much thickened gall-bladder could be felt completely surrounded by liver tissue. In the gall-bladder could be palpated a solitary rounded calculus the size of a hazelnut. The left lobe was also somewhat lobulated. The falciform ligament did not as usual separate the right from the left lobe, but emerged from the centre of the liver a rather deep groove

near the centre of the organ, which abruptly became shallower toward the anterior edge, where it terminated in a small notch, indicating the division between the two main lobes. Both the upper and under surfaces of the left

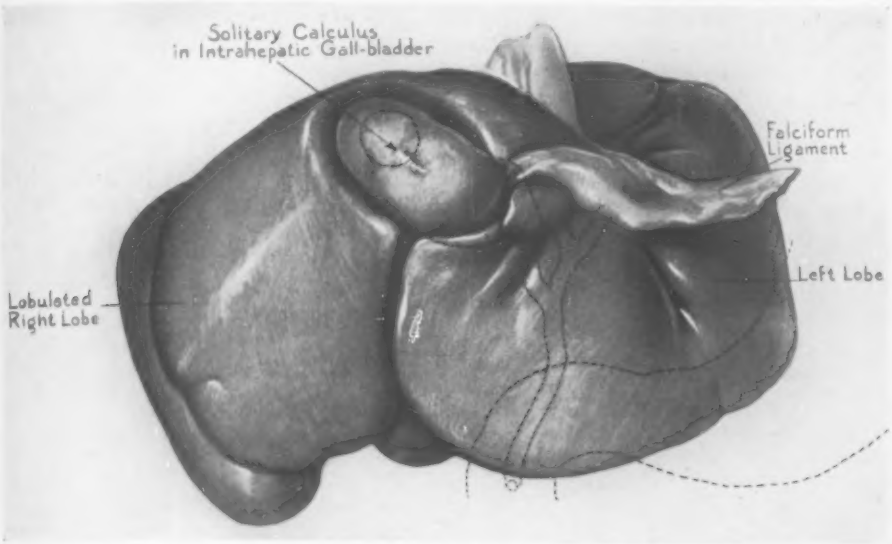

FIG. 14.—Upper surface of liver in case of intrahepatic gall-bladder.

lobe showed several marked indentations, indications of incomplete lobulation. It was found that the fissure in the liver leading to the gall-bladder could be separated without much difficulty so that the medial part of the right lobe

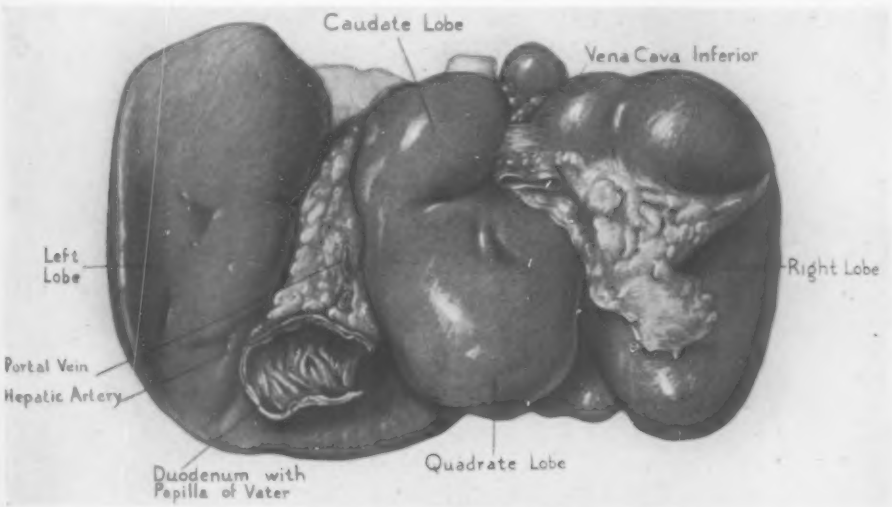

FIG. 15.—Under surface of liver in case of intrahepatic gall-bladder.

could be split apart and the large lip of liver tissue to the left could be deflected medially, and a relatively simple cholecystectomy from above downward could be done, with very definite separate ligation of the cystic vessels and cystic duct and cauterization of the cystic-duct stump. The gall-bladder

was rather adherent to its bed in the liver and there was a very profuse hæmorrhage from this region, which could be fairly well controlled with gauze tamponade, but which baffled somewhat protracted attempts at clamping or suturing, owing to its inaccessibility under the costal arch and diaphragm. It was finally decided to leave the tampons in the oozing liver bed, and the abdomen was closed in the usual manner.

The gall-bladder was a much diseased, thick-walled organ, the mucosa showing a large gangrenous patch near the fundus on the liver bed side. The balance of the mucosa was scarred. The gall-bladder contained a solitary, rounded, somewhat roughened, brown calculus the size of a hazelnut. It also contained a moderate quantity of thick, muddy, brown fluid. Microscopical examination of the gall-bladder revealed a chronic ulcerative cholecystitis. The patient was very much shocked after the operation and in spite of multiple transfusions, hypodermoclyses and proctoclyses, never really reacted. The wound drainage was rather sanguinous at first but rapidly became serous. There was never any actual post-operative hæmorrhage. The patient, however, developed a rising temperature and pulse rate, abdominal distention and tenderness and vomiting, symptoms suggestive of peritonitis, and expired about fifty-eight hours after operation. A study of the liver entirely confirmed the operative findings. In addition, a small, irregularly ovoid lobe about the size of a hen egg was found at the upper posterior portion of the right lobe, just to the right of the groove for the inferior vena cava. It was almost completely separate from the main organ, being attached by an extremely thin strand of liver tissue. The relations of the common bile-duct, portal vein, hepatic artery, inferior vena cava, and caudate lobe were relatively normal. The hepatic ducts were not dissected out as it was desired not to damage the unique specimen.

This case illustrates an anomaly that is said to be not uncommon, but which Doctor Stetten has encountered for the first time. Mentzer in the Journal of the American Medical Association of November 17, 1929, refers to this condition and speaks of cases reported by Wieder, Lemon, Deve, O'Day, Yoell, Schachner, Kehr, and himself. He regards the condition as a revision to the form normally occurring in certain of the lower animals. The case is reported by Doctor Stetten because he believes that, had the technical difficulties and dangers been properly anticipated, a cholecystectomy would not have been attempted. The gall-bladder could have been opened, the calculus extracted, and a simple cholecystostomy performed. This might not have been entirely simple, owing to the position under the diaphragm, but with some sort of L-tube, it might have been accomplished. Death was undoubtedly caused by shock, and peritonitis, resulting from hæmorrhage, protracted manipulation, and the subsequent necessity for extensive gauze drainage, which could have been avoided by the simpler operation.

PARA-ŒSOPHAGEAL ABSCESS

Dr. Arthur S. McQuillan presented a woman who entered Bellevue Hospital, October 22, 1931, with a tender indurated swelling in the region of the left lobe of the thyroid gland. There was a sense of deep fluctuation in this region. The swelling appeared maximum at the inner border of the sternomastoid at its middle. About ten days before admission to the hospital, she had swallowed a fish bone, which she felt lodged in the upper œsophagus. The bone remained there for one week, when she dislodged it by gargling but soreness and pain in the left side of the neck persisted.

Over the maximum swelling about the middle of the sternomastoid, a three-inch transverse incision was made under local anæsthesia. Thick pus

welled up from an opening between the sternomastoid and omohyoid muscles. About three ounces of pus was evacuated and this had the odor of colon bacillus—which was proved by culture. This abscess cavity was found to lead down to the cervical vertebræ along the side of the œsophagus. With drainage the patient made a good recovery in two weeks.

The reason for presenting this case is for the interest attached to infections in this para-œsophageal space and the relation of these infections to œsophageal diverticula.

RECURRENT DIVERTICULUM OF THE ŒSOPHAGUS

Doctor McQuillan presented also a woman who was presented before the New York Surgical Society December 11, 1929. Three months previous she had had a two-stage operation for diverticulum of the cervical œsophagus on the left side. The patient remained symptom-free for a period of nine months, when she began to have distress in swallowing and all the former symptoms reappeared with increased severity.

X-ray showed a diverticulum on the same side nearly as large as the first one. Molds of food as large as one's thumb were regurgitated from this sac. A No. 18 œsophageal bougie easily entered this sac, and one could feel this bougie by palpating on the left side of neck. It was impossible to get this bougie to pass the sac into the lower œsophagus.

Operation was undertaken, October 31, 1930, through the old scar. There were scarcely any adhesions, and no difficulty in identifying and isolating the diverticulum, which was much larger than appeared in the X-ray. In fact the sac was found to be formed by the whole left side of the cervical œsophagus, there being no distinction between neck and fundus. Also, the wall of the sac was exceedingly thin, which is contrary to the usual findings in œsophageal diverticula.

It was obvious that any attempt of excision would result in extirpation of the whole left wall of the œsophagus. For this reason the sac was obliterated by a multiple infolding or plication of its wall, with an œsophageal bougie in place to prevent obliteration of the entire lumen.

With the exception of a hoarse voice lasting three weeks, the patient made a good recovery and has been symptom-free to the present time. However, X-ray shows beginning diverticulum on the right side, which has given no symptoms thus far.

Dr. Gaston A. Carlucci quoted a similar case under his care in 1927. Recently she returned to have another X-ray taken. The diverticulum had been removed in one stage, after which the patient had no symptoms. Now, five years later, she had a little diverticulum present. The original removal was by complete extirpation, the end being turned in.

Dr. Franz Torek said that recurrences happened after all kinds of operations for diverticulum of the œsophagus. In the one-stage operation they recur less frequently than in any other. The preference for the two-stage operation has been based on the belief that it is safer as far as mortality is concerned. Thirty years ago the mortality was very high with the one-stage procedure, but in the last five years sixty cases have been recorded with a mortality of only one. The most certain result as far as absence from recurrence is concerned is the one-stage operation.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY

STATED MEETING HELD APRIL 4, 1932

The President, Dr. John Speese, in the Chair
Calvin M. Smyth, Jr., M.D., Recorder

VENTRAL HERNIA—HERNIOPLASTY—LIPECTOMY

Dr. Hubley R. Owen presented a woman, aged fifty-six years, who was admitted to the Philadelphia General Hospital January 22, 1932, with the chief complaint of incisional hernia. In 1925, she had had laparotomy for prolapse of the uterus and a second gynæcological operation in 1930. Shortly after the second operation she fell heavily to her knees and thereafter noticed a swelling in the abdominal wall which had been increasing in size and for the past few months has been painful.

Fig. 1.

Fig. 2.

Fig. 1.—Ventral hernia before operation.
Fig. 2.—Result of operation on condition shown in Fig. 1. Photo taken four weeks after operation.

The examination of the abdomen disclosed below the umbilicus a large misshapen protrusion which hung like an apron (Fig. 1) along with natural adiposity over pubis. This mass contained gurgling gut. An ill-defined rectus diathesis could be palpated

At operation, two longitudinal, eliptical incisions were made from below the ensiform cartilage to above the symphysis. Subcutaneous tissues and peritoneum dissected free of hernial sac. An area of skin and subcutaneous tissue measuring ten inches by nine inches was removed. The contents of hernial sac were replaced in the abdomen. Peritoneum was closed and both the posterior sheath and the anterior sheath of the rectus muscle were overlapped and sutured with interrupted No. 2 chromic gut. When the closure

of the skin and subcutaneous tissue was undertaken it was found on account of the large amount of tissue removed that it was necessary to "pie-crust" (Fig. 2) on either side of the suture line in order to relieve the strain on the skin sutures. The patient was discharged February 16, 1932, twenty-one days after operation.

LOCALIZED TUBERCULOSIS OF THE CHEST-WALL

Dr. Richard H. Meade, Jr., read a paper with the above title for which see page 247.

ELEPHANTIASIS NOSTRA

Dr. George P. Muller and (by invitation) Dr. Claus G. Jordan read a paper with the above title for which see page 226.

SPLENIC ABSCESS

Dr. Eldridge L. Eliason reported the case of a man, aged twenty-three years, who was admitted July 21, 1931, to the Medical Service of the University of Pennsylvania Hospital, complaining of pain in the left side of chest following rupture of a left peritonsillary abscess. He had developed sore throat June 16, 1931, and was admitted to the hospital June 20, 1931, after a fainting spell, associated with a very high fever. While in the hospital a left peritonsillar abscess ruptured June 25. On the next day a severe pain was noted in left side of the chest near costal margin in the anterior axillary line. This pain spread to entire left upper quadrant of the abdomen. Decided tenderness to palpation was noted over the left upper abdominal quadrant. The patient was coughing up profuse mucopurulent sputum and was experiencing nausea, vomiting, weakness and sweating He had had definite chills and his temperature was 104.2°.

Fluoroscopical examination of the chest July 22 disclosed a small empty abscess cavity in the right upper lung, with a fluid level beneath the diaphragm on the left side lateral to the stomach; and a fixed left diaphragm indicative of subdiaphragmatic abscess. X-ray examination July 25 showed in the lateral view that the abscess in the right lung was in the base of the upper lobe. A blood culture showed a staphylococcic septicæmia. A surgical diagnosis of (1) splenic infarct with abscess formation secondary to acute tonsillitis was made and drainage advised; (2) lung abscess and septicæmia (the former appears to be draining adequately by the postural method of treatment).

Following a transfusion of 250 cubic centimetres of blood the patient was operated upon July 27 through a left modified Kocher incision. On opening the peritoneal cavity there was a gush of reddish-gray purulent matter, evidently under pressure and accompanied by a malodorous gas, comparable to that draining from the peritonsillar incision. Approximately one litre of pus evacuated. Pulp-like tissue escaped in shreds, not unlike splenic pulp. Soft rubber tissue cigarette drains were inserted and wound packed with plain gauze. The pulse was 160 at the close of operation, which took fifteen minutes. The patient was again transfused after operation, but he became progressively worse and succumbed about twenty-seven hours later. The post-operative course was marked with a severe hyperthermia, the temperature reaching 108°.

At an incisional post-mortem, the spleen was found the seat of an enormous abscess which had ruptured, causing a localized subdiaphragmatic abscess bounded by the liver, stomach, colon and lateral abdominal wall. It

contained pus and small quantities of soft mushy tissue, which on extraction were found to be portions of the spleen which had undergone necrosis and sequestration. The right lung showed a large abscess. Further exploration was not permitted.

DOCTOR ELIASON remarked that abscess of the spleen is thought to be a rare disease. This fallacious idea is due to the fact that it is rarely reported as such, because it is seldom diagnosed and treated surgically. It is, however, frequently found at post-mortem as a complication in septicæmia, typhoid fever, relapsing fever, *etc.*, its existence before death not being suspected or rather being masked by the serious nature of the primary disease. The above case was diagnosed and treated surgically although with fatal result. It illustrates also the sequestration phenomenon noted by Kuttner in his series of abscessed spleens.

ECHINOCOCCUS CYST OF THE LIVER

DOCTOR ELIASON reported the case of a man who was admitted to the hospital of the University of Pennsylvania April 7, 1927, complaining of severe pain in the mid-epigastrium. The patient had been perfectly well until three years and five months before admission, at which time he was seized with a severe pain in his upper abdomen which doubled him up, persisting for ten minutes, and then disappeared entirely. These attacks became periodic in type, recurring at intervals of from three weeks to two months, and lasting from ten minutes to twelve hours each time. Soon after the original attack the patient was admitted to the New York Polyclinic Hospital where X-ray studies and duodenal drainage were done. He was informed that all examinations at that time were negative. The pain had no relation to food and was not accompanied by nausea, vomiting, dizziness or headache. It was severe, usually localized in the mid-epigastric region, though it occasionally radiated through to the interscapular region posteriorly. Nausea and vomiting appeared as a feature only with the attack immediately before the patient's admission to the hospital. There were no other gastro-intestinal symptoms in the patient's past history and the cardiorespiratory, nervous and urological systems were negative.

When admitted the upper recti were markedly rigid and there was definite tenderness about one inch below the ensiform cartilage in the mid-line. The lower recti were soft, the liver, spleen and kidneys were not palpable and no other masses were made out. Peristalsis was absent. The leucocyte count on admission was 22,300. The fluoroscope revealed a large mass extending upward from the anterior portion of the right lobe of the liver, considered to be probably non-inflammatory since the diaphragm moved readily above it. In view of this finding immediate operation was postponed. The following morning the abdomen was soft, the temperature, pulse and respirations normal and the patient felt quite comfortable. The leucocyte count had fallen to 11,900. Because of the X-ray findings, the slight icterus and the patient's nationality (Greek), a tentative diagnosis of echinococcus cyst of the liver was made which was further confirmed by the presence of a positive complement fixation test for hydatid disease.

The following day a portion of the right tenth rib in the mid-axillary line was resected, the diaphragm was sutured to the pleura and the wound packed with gauze. Two days later a needle inserted into the cyst cavity obtained typical "spring water" fluid and a cautery was carried along its

course toward the cyst. As there did not appear to be sufficient adhesions present between the liver and the diaphragm at this time, however, and to prevent the possibility of peritoneal soiling, the wound was again packed with gauze for three days. May 2, 1927, the cyst was entered by means of the cautery. It was found to be about the size of an orange, filled with daughter cysts of all sizes and containing a quantity of yellow mucoid material. After removing many of the cysts the cavity was packed with gauze. Four days later the gauze was removed and the cavity explored by means of a cholecystoscope. Many small daughter cysts were found lining the wall of the cyst cavity; about a cupful of these were removed with moderate difficulty. During the next few days the general condition of the patient rapidly improved, the drainage from the cyst cavity decreased and he was discharged to the surgical out-patient department. Four months later he was enjoying excellent health, at his old work and symptom-free.

The patient had no symptoms until January 1, 1932, when, after a heavy meal, he again experienced a moderately severe pain in the epigastrium which continued for twelve hours. This was followed by a feeling of soreness which extended from the epigastrium down to the anterior superior spine on the right. For the next four days he remained in bed, felt feverish and experienced several chills, although his appetite was good and there was no digestive upset. He was admitted to the hospital January 5, 1932, with a temperature of 99°, pulse 84 and respirations 20. In the abdomen a large mass was palpable extending down from the right costal margin to the level of the umbilicus. The mass moved with respiration, had a definite edge, was moderately tender and extended on percussion to the fourth right interspace in the mid-clavicular line. Recurrent echinococcus disease of the liver was evident. Surgical drainage was instituted by means of the transthoracic approach in two stages. The cavity in the right lobe of the liver was found to be about the size of an adult fist. From this approximately a cupful of daughter cysts of varying size were removed. At operation the cysts were seen attached to all sides of the cavity. Palpation revealed the presence of some calcification in the wall of the cavity beneath the daughter cysts. The cavity was packed with gauze and a large drainage tube inserted. Postoperatively the patient drained great quantities of bile-stained serum, in which many daughter cysts could be seen. Irrigations with 1.5 per cent. iodine solution were instituted but the pain incident to these irrigations was so great that they had to be stopped even though the concentration was reduced to .5 per cent. An X-ray plate taken after the injection of lipiodol into the sinus showed the entire hepatic duct system plainly outlined, the ducts appearing somewhat larger than normal. The hepatic ducts and the common duct were particularly dilated, but a small portion of the lipiodol was seen to enter the duodenum. This plate demonstrated conclusively an existing connection between the echinococcus cyst and the biliary tree and suggested the presence of some obstruction in the common duct. The patient continued to discharge great quantities of bile through the wound, although there were no signs of biliary insufficiency manifest. The biliary drainage decreased gradually though he continued to require two dressings per day. March 1, 1932, the patient was discharged to the care of his family physician. At this time there was no jaundice, the stools were brown and he was free from all symptoms except the profusely discharging biliary fistula at the operative site.

March 10, 1932, the biliary drainage from the fistula ceased and coincident with this the patient developed chills, fever, pain in the epigastrium and became definitely jaundiced with acholic stools. His physician probed the

biliary sinus which resulted in a great outpouring of bile and the jaundice with its accompanying symptoms promptly disappeared within the next few days. The man was again admitted to the hospital March 17, 1932. On this admission there was no definite jaundice although the sclera had a subicteroid tinge. The biliary fistula in the right chest continued to discharge copious quantities of bile each day. The stools were brown and the urine showed no bile salts. Under gas-ether the abdomen was opened through a modified Kocher incision. The gall-bladder was of normal thickness and color, was not distended and contained no stones. Palpation of the superior surface of the liver showed this tightly adherent to the right diaphragm. There were many adhesions along the cystic and common ducts. The cystic duct was but slightly dilated, while the hepatic duct when seen was found to be greatly enlarged, being approximately the size of one's thumb. The common duct as it passed behind the duodenum was also seen to be similarly dilated. The gall-bladder was opened and found to contain no bile. It was then carefully explored with the cholecystoscope but no calculus was found which might account for the absence of bile from the gall-bladder. The hepatic duct was then opened and found to be filled with bile in which streaks of purulent material were noted. A catheter introduced into the common duct through the hepatic duct readily entered the duodenum. Flushing out the common duct with normal salt solution failed to disclose the presence of any calculus or daughter cysts in this portion of the ductal system which might be responsible for the obstruction. The catheter was then passed up the hepatic duct into the liver. Approximately five centimetres up the hepatic duct, within the liver, a partial obstruction was encountered, although the catheter could be forced by this point. Instilling salt solution in the hepatic duct through the catheter resulted in the discharge of several small typical daughter cysts through the opening in the hepatic duct. It was therefore felt that the obstruction was of the partial type, due to the transplantation of echinococcus cysts, located high in the hepatic ducts. Drainage of the common duct or a cholecyst-duodenostomy in such a case would serve no useful purpose so the incision in the hepatic duct was closed and a drain placed to this site. A cholecystostomy was performed and the abdomen was closed. Post-operatively the patient did well. Small quantities of bile were discharged through the cholecystostomy tube although the biliary sinus in the chest continued to discharge considerable quantities of bile requiring daily dressings.

INTRAMURAL ABSCESS OF THE STOMACH

Dr. L. K. Ferguson reported the case of a colored woman, thirty-eight years old, admitted in the service of Dr. E. L. Eliason at the Philadelphia General Hospital March 29, 1931, complaining of severe epigastric pain. Following a drinking party one week before admission, the patient had an attack of acute upper abdominal pain associated with marked vomiting and elevation of temperature. Her pain continued and became localized slightly to the right of the mid-line in the epigastrium. There was radiation of the pain to the back and to the right shoulder. Two years before admission the patient had a severe gastric hæmorrhage which was thought to be due to a gastric ulcer. Since that time she had suffered from occasional gastric upsets usually following the taking of alcohol in excess.

There were no abnormal signs in the lungs. The abdomen was distended and was markedly tender and rigid in the epigastrium, especially on the right side. No masses were palpable. Peristalsis was greatly diminished. A scar of a previous operation in the lower abdomen was not tender. The blood

count showed 4,620,000 red cells and 21,200 white cells of which 92 per cent. were polymorphonuclear leucocytes. A flat plate of the abdomen showed no gas under the diaphragm and was reported as not suggestive of a ruptured viscus.

The abdomen was opened through a right rectus incision under spinal anæsthesia. A small amount of clear, straw-colored fluid was aspirated. An examination of the stomach showed a diffuse thickening of the pyloric end, more marked on the lesser curvature and anterior wall. There was marked œdema of the tissues of the gastrohepatic omentum which extended upward to involve the subhepatic structures. The gall-bladder was indurated but did not contain any stones. Clear, yellowish bile was aspirated from it. No pathological condition could be found in the lesser peritoneal cavity. A cholecystostomy was performed and the wound was closed about the tube.

The first post-operative day was uneventful. On the second day the abdomen became distended and peristaltic sounds were diminished. Glycerine enemas appeared to relieve the distension somewhat. Temperature and pulse gradually increased. On the evening of the third day when the distension was still marked the patient was found out of bed. During the night she was delirious and incontinent. The pulse and temperature gradually mounted, the distension increased and the patient died on the morning of the fourth post-operative day.

Post-mortem examination revealed a generalized fibrino-purulent peritonitis. The stomach was the seat of an acute phlegmonous process. About two centimetres above the pylorus there was an abscess lying between the mucosa and muscularis. The abscess cavity was about six centimetres in diameter and contained about ten cubic centimetres of fluid pus. There was marked induration and œdema of the surrounding stomach wall. The duodenum also was involved in the acute inflammatory process and there were many ulcerations of the mucosa.

Doctor Ferguson remarked that Rankin and Miller have recently reported that abscesses of the gastric wall form about 12 per cent. of the purulent inflammatory lesions of the stomach. They occur so infrequently, however, that the diagnosis is rarely made except at operation or at necropsy. As a rule they represent an advanced stage of phlegmonous gastritis, the exciting causes of which may be grouped under five general heads: food, alcohol, chemical irritants, infections and infectious fevers. In addition, local inflammatory lesions may be set up by occupational, accidental or operative trauma to the stomach wall. The abscesses are usually located in the submucosa but they may involve all the layers of the stomach.

The predominating organisms are usually streptococci or staphylococci and occasionally pneumococci. The surgical treatment of gastric abscess is attendant with a very high mortality. Incision and drainage, excision and drainage and gastric resection have occasionally been used in the treatment of this condition. It occurs so rarely, however, that the lesion is often not diagnosed even at operation. Symptoms of gastric abscess are varied. The patients are usually young and often the history may be obtained of an alcoholic debauch or some food intoxication. There is sudden loss of appetite, nausea and vomiting occur, and vomiting becomes a prominent symptom. As a rule, the fever is high, varying between 103° and 105° and is often of the

septic type. On examination there is marked pain and tenderness in the epigastrium, at times referred to the back and to the shoulder. The X-ray findings usually are interpreted as gastric ulcer.

MUSCULOSPIRAL PARALYSIS—TENOPLASTY

Dr. George M. Dorrance presented a boy, aged nine years, who was admitted to St. Agnes' Hospital September 1, 1931. Four years prior to admission this child was struck by an automobile and sustained a compound fracture of the humerus and severe laceration of the upper arm. He was treated in another institution. All the muscles of the upper arm were torn loose from their points of insertion and the skin and fascia was devitalized over a large area. The musculospiral nerve was exposed and during the fifteen weeks' stay in the hospital, it ruptured and the ends became buried in the scar tissue. The infection cleared up before his discharge. He had practically no power to raise his forearm; he had wrist drop. One year prior to his admission to St. Agnes' Hospital, Doctor McShane and the reporter reunited the ends of the musculospiral nerve but as there was no return of function he was admitted for a tendon transplantation. September 2, 1931, the following operation was performed: The tendon of the flexor carpi radialis was cut close to its insertion at the base of the second and third metacarpal bones; the tendon of the flexor carpi ulnaris was also cut close to its insertion in the pisiform bone. Next the four tendons of the extensor communus digitorum and the extensor longus policus were exposed just above the posterior anular ligament. Each of these tendons was slotted—then the free end of the tendon of the flexor carpi radialis was threaded through from the radial side and drawn out for a distance of one inch on the ulnar side. The flexor carpi ulnaris tendon was threaded through from the ulnar side and drawn out for an inch on the radial side. The free ends were turned back on themselves and sutured. A suture was placed through each of the tendons also at the openings in the communis digitorum and extensor longus policis. The wounds were closed and for four weeks the arm was placed in a plaster case with the wrist extended. After four weeks massage was begun and passive motion instituted. The child was encouraged to move the wrist. Almost complete restoration of the power of extension was accomplished by this procedure.

March 31 the patient was examined by Dr. Milton Meyers who tested the extensor muscles and the supinator longus to see if the musculospiral nerve had regenerated, so perfect was the function. Doctor Meyers had examined this patient before the operation and reported that the muscles supplied by the musculospiral had undergone atrophy and showed signs of degeneration. Today he reports partial return of musculospiral function. This illustrates the point that return of function after nerve suture may not manifest itself for eighteen months or longer.

TEMPOROMANDIBULAR ANKYLOSIS

Dr. George M. Dorrance presented a girl, aged six years, who was admitted to St. Agnes' Hospital November 21, 1931, with the diagnosis of bony ankylosis of the left temporomandibular joint. At the age of one year, a large cervical abscess complicating septicæmia developed. Incision and drainage was performed and the patient was under medical supervision for four months. Eight months later, she developed a septic sore throat. In attempting to treat this, the physician forcibly opened the jaws. Since then, according to the mother, the jaws became fixed. Physical examination was negative

except for the complete bony ankylosis of the left side of the jaw. X-ray snowed atrophic bone changes in articular process of the left side and complete bony ankylosis.

November 13, 1931, under ether anæsthesia, resection of the left mandibular joint was done. Not only was the condyle fixed but the coronoid process was fixed by ossification to the base of the skull. It was necessary to resect about one inch of the bone. Convalescence was complicated by an acute otitis media but was otherwise uneventful. The patient was instructed to open and close the jaws every fifteen minutes after the tenth day. This procedure was painless from the start—the chewing of gum proved to be a valuable adjunct in keeping the jaws in motion. At the present time she has no difficulty in opening the jaws to the normal limits.

RESECTION OF MANDIBLE

Dr. George M. Dorrance presented two patients operated upon for malignancy of the jaw. The first patient was a man who was operated upon twelve years ago by the later Dr. Francis T. Stewart, at Jefferson Hospital, for a multilocular cyst. Recurrence of the condition led the reported to do a resection of the lower jaw, after having ligated the external carotid artery.

This man has had metastasis to the glands of the neck, a fact not sufficiently emphasized when discussing the relative benign nature of adamantinomas. He wears a double inclined plane appliance made by Doctor Webster and has little deformity and can masticate quite satisfactorily.

The second case was that of a woman who had had one-half of the jaw resected for a sarcoma. She does not wear any splint or appliance. Unfortunately, a local recurrence necessitated removing the bone well beyond the mid-line into the second incisor area on the opposite side. Doctor Dorrance has been agreeably surprised to find that while this procedure did increase the deformity considerably, it has caused comparatively little disturbance to the patient.

These two cases were shown to illustrate the fact that when necessity dictates resection of half the jaw, the ensuing deformity need not be too seriously considered.

ARTHROPLASTY OF JAW FOR ANKYLOSIS

Dr. A. Bruce Gill presented two patients on whom an arthroplasty of the jaw had been done. The first patient was operated upon in 1927, when five years of age. When she was a baby she had pyogenic infection of the right hip which was not recognized. She was being treated for tonsillitis for a number of weeks. During that time an abscess developed in the region of the right temporomandibular joint which was opened and drained. Bony ankylosis resulted. The lower jaw did not develop with the other bones of the face. At the present time she has normal mobility of the jaw and the lower mandible has developed almost to normal size.

The second patient was operated upon January 21, 1932. She is eleven years of age. The ankylosis of the temporomandibular joint occurred when she was two years of age. At the time she was in the Municipal Hospital for a period of sixteen weeks with scarlet fever, diphtheria, pneumonia, mumps and measles in succession. She had a blood-stream infection which produced abscesses in the left thigh and the left arm and wrist. A bony ankylosis of both temperomandibular joints resulted. Bilateral arthroplasty was done. At the present time she is able to open her mouth about one and a half inches and the range of motion is increasing

Doctor Gill did his first operation for this condition in 1919. His method of operation has always been as follows: Incision is made through the skin about one inch in length along the lower border of the zygoma. Another incision of the same length at a right angle to the first one is carried down just in front of the ear. The soft tissues are divided down to the lower border of the zygoma and are pushed downward by blunt dissection. In the majority of his cases it has been found that both the condyle and the coronoid process have been ankylosed to the skull with obliteration of the sigmoid fossa. With a thin-bladed osteotome the ramus of the jaw is divided about one-half inch below the lower border of the zygoma and then the upper portion of the mandible is separated from the zygoma in the same way. If this is done carefully no injury is done to vessels, nerves or parotoid gland. A piece of superficial fascia and fat is removed from the thigh and placed between the skull and the mandible. The wound is closed without drainage.

The after-treatment consists in keeping the mouth open with plugs made of rubber or with a wooden screw or with dental plates which have arms attached to them to which are fastened rubber bands. It has been found that these mechanical means are not needed after the first two or three weeks as the patient then begins to move the jaw freely. One case of relapse occurred in a patient in whom he did not interpose any soft tissue between the bones at the time of operation. A second operation was necessary. It resulted in good function. In practically all of the speaker's cases the condition was due to a pyogenic infection apparently accompanied by the presence of osteomyelitis in other parts of the body. After function of the jaw is established it has been found that the jaw develops. Of course, the younger the patient at the time of operation the more rapid and more complete is the result.

BRIEF COMMUNICATIONS

THE OVERSLUNG TRACTION SADDLE FRAME

FOR THE TREATMENT OF FRACTURES OF THE PELVIS AND LOWER EXTREMITIES

THIS frame may be used where the conveniences of a fracture bed or the Bradford frame are indicated, but has many advantages over either. It provides for:

(1) The patient to lie naturally on the mattress of the bed, thus eliminating decubitus.

(2) Traction and fixation of lower extremities in any manner desired.

(3) Raising and lowering of the patient without disturbing traction and fixation.

(4) Nursing attention, such as use of the bed pan, bathing, changing linen and turning of mattress.

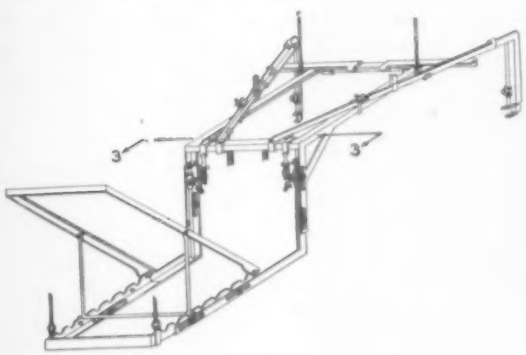

FIG. 1.—Details of frame construction.

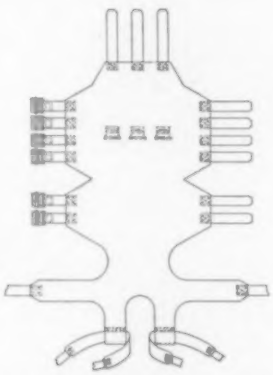

FIG. 2.—Details of canvas saddle.

(5) Transportation of patient without disturbing fixation and traction.

(6) Headrest adjustment and sitting position.

(7) Tilting patient where hypostatic pneumonia is threatening.

(8) Access to X-ray or fluoroscopic examination.

Its greatest usefulness is in fractures of the neck of the femur in the aged. The fragments may be reduced without anæsthetic or removal of patient from the bed. The reduction is slowly and painlessly accomplished by the Russell method of traction. Adhesive is applied to the leg as for Buck's extension. A band around the knee is attached to the rope which extends over a pulley above, then to triple pulleys at the foot, thus producing flexion of the knee, internal rotation and traction by a single weight.

The frame is constructed of No. 1 by 1 by 3/16 inch angle iron. (Fig. 1.) It forms a two-section rectangle, 36 inches wide and as long as the bed, in which the upper half rests on the bed mattress and supports the trunk and

pelvis by means of its canvas saddle (Fig. 2) which is stretched between the bars of the frame, while the lower half is overslung above the extremities and provides suspension, fixation and traction for them. This removes all bars and framework from under the legs so that extension or abduction of the legs may be obtained without having the interference. Two adjustable arm bars hook onto the transverse bar at the middle of the frame and extend out over the lower rectangular frame and drop down at the end to furnish support for the pulleys. Countertraction is furnished by a padded aluminum band around each thigh at the groin and hooked by snaps to the frame above. The canvas support under the back and pelvis is buckled to this band so that the patient can slide downward no farther than the tension of the canvas

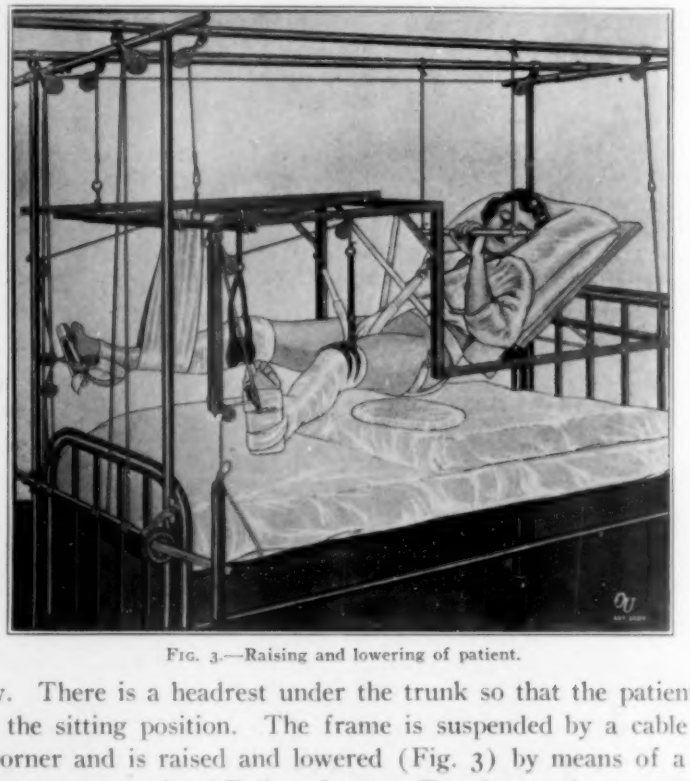

FIG. 3.—Raising and lowering of patient.

will allow. There is a headrest under the trunk so that the patient may be raised to the sitting position. The frame is suspended by a cable attached to each corner and is raised and lowered (Fig. 3) by means of a windlass and pulleys on an overhead Balkan frame. Traction to the extremities may be applied in any of the forms in common use.

EARL D. MCBRIDE, M.D.
Oklahoma City, Okla.

TREATMENT OF INTRACAPSULAR FRACTURES OF THE NECK OF THE FEMUR

IN THE last (tenth) edition, 1931, of Pye's Surgical Handicraft, designed for house surgeons and dressers, the rising generation, the treatment of intracapsular fracture of the neck of the femur is described as follows:

"The patient should be propped up in bed with the limb placed between sandbags. After about a month the patient is advised to use the limb as much as possible since union is not aimed at."

This is virtually a transcription of the teaching of Sir Astley Cooper, which was based on the conclusion that mechanical appliances were inadequate to assure the essentials of repair. Consequently, that positive treatment of the fracture was both futile and dangerous. This conclusion, which has been generally accepted, is verified by recent experience.

In 1928, Katzenstein of Berlin (Zent. f. Chir. L. v., p. 239), reported on 169 cases of medical fracture treated in the conventional manner. Good results were attained in but 11.6 per cent. of the number, a percentage which, according to Auxhausen, who discussed the paper, fairly represented the general experience.

In 1930, Hübner (Arch. f. Orth. u. Unfall. Chir., 1930) reported on 136 cases treated at the Charity Hospital in Berlin. Good results were attained in but 6 per cent. and passable function in 16 per cent. of the patients.

The most recent statistics available for comparison are those of Stern and Henderson. Stern has reported on the results of seventy-nine cases of medial fracture treated by the abduction method at the Mt. Sinai Hospital in Cleveland, with a mortality of 7 per cent. and union in 67 per cent. Seventeen of the patients were over seventy years of age yet union was attained in 78.5 per cent. (Surg., Gynec., and Obst., August, 1931).

Henderson reports on forty-two cases treated at The Mayo Clinic. Union was attained in 90 per cent. of the patients under sixty and in 65 per cent. of those over that age. (ANNALS OF SURGERY, vol. xciii, p. 968, 1931.)

In all reports available for comparison, the balance, as in this instance, in favor of positive over negative treatment, must be reckoned in multiples of 100 per cent.

One may conclude, therefore, that the real obstacle to the general adoption of the abduction treatment is inertia, or more specifically, to quote Mosenthal (Med. Klinik, vol. xxv, p. 384, 1929), inability to meet its requirements.

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TECHNIC FOR CARE OF OLLIER-THIERSCH SKIN GRAFTS

THE application of a graft is a simple matter but many surgeons are bewildered when it comes to the after-care. Paraffin gauze, rubber strips, adhesive plaster, wire splints, exposed wound, cello silk, marine sponge and vaseline gauze are some of the dressings in use. A recent article advocates a rigid dehydrating diet for the recipient before grafting, thus drying the granulations, which is to aid agglutination of the grafts. Practically all these dressings and methods were devised solely for the purpose of splinting or approximating the grafts until they take.

To obtain the best results in wound repair three fundamental principles

in surgery must be observed; first, there must be constant, even, gentle pressure of the opposing surfaces, that is, adequate approximation; second, there must be constant splinting of these surfaces; third, the wound must be kept free from secretions and infection. A violation of these principles in the art of skin grafting is much more disastrous than in the closure of a lacerated or an incised wound. During the first twenty-four hours the grafts become agglutinated at the base by a coagulation of lymph; this is followed gradually by connective-tissue and capillary infiltration until firm union occurs. Grafts are parasites and do not become a part of the host until about the tenth day. It is during this insecure period that it is difficult to comply strictly with these principles by the present methods, especially when the dressing is removed to cleanse the wound. To obviate this difficulty these dressings are

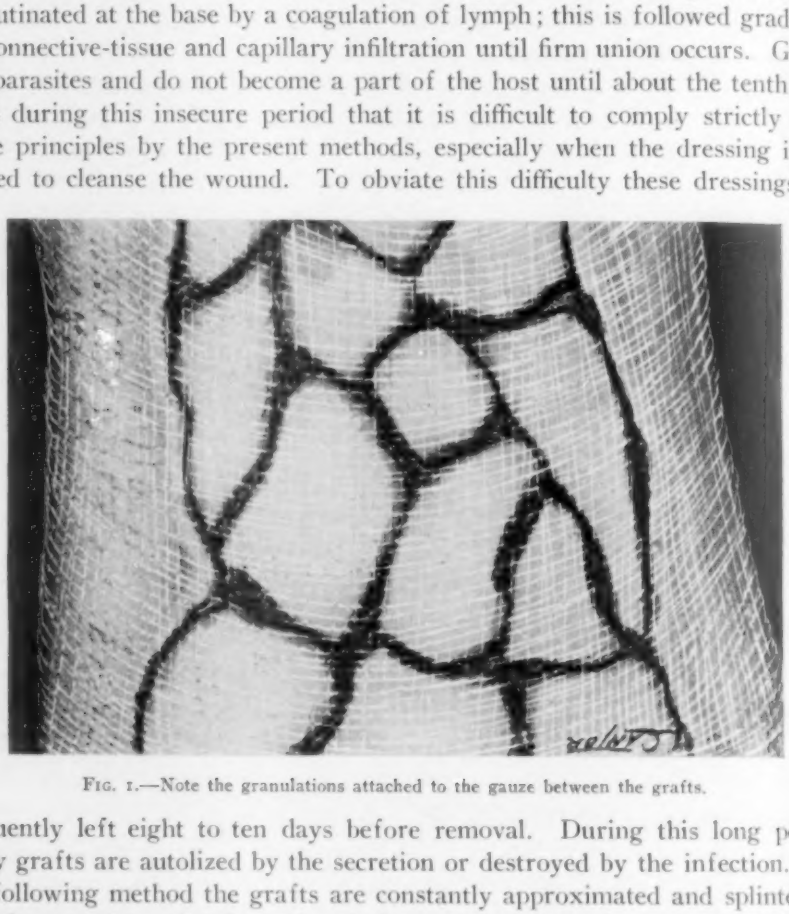

FIG. 1.—Note the granulations attached to the gauze between the grafts.

frequently left eight to ten days before removal. During this long period many grafts are autolized by the secretion or destroyed by the infection. By the following method the grafts are constantly approximated and splinted so that the wound may be dressed and cleansed as frequently as desired without danger to the grafts.

The technic.—Assuming that the surface to be grafted has been properly prepared and the Ollier-Thiersch grafts applied in the usual manner; then place a single layer of gauze (20 by 16 mesh) snugly over the grafted area and extend it around the limb and sew it together on the opposite side. If the grafted area is in an inaccessible place extend the gauze for a considerable distance from the wound and fix the edge with adhesive or collodion. The wound is then covered with a sterile dressing one-half inch thick and kept moist with normal saline. Within twenty-four hours the single layer of gauze becomes attached and buried in the granulations between the grafts

and shrinks sufficiently to make it taut. Thus each graft becomes enclosed in a compartment surrounded by a wall of granulation tissue, and covered with the single layer of gauze. (Fig. 1.) The top dressing can now be removed as frequently as desired (after saturating with normal saline) and the wound irrigated without disturbing the grafts in the least. There is always a certain amount of swelling due to the inflammatory reaction underneath the grafts; this with the shrinkage of the single layer of gauze, which is buried in the granulations between the grafts, gives adequate pressure to encourage union. On about the tenth day the single layer of gauze is removed. The firmness with which the grafts were splinted and approximated will now be appreciated. It will require considerable pulling to free the single layer of gauze from the granulations and some bleeding will occur. The wound is then irrigated with normal saline. The grafts now being well united, are covered with a single layer of radium silk and top-dressed as before. This dressing including the silk may also be changed as frequently as desired without injury to the grafts. The granulations cannot attach themselves to the smooth, closely woven silk and it flattens the granulation on a level with the grafts, making a very smooth surface. It is surprising how rapidly the epithelium spreads beneath the silk and in a few days the wound is completely healed.

Although I have never used this technic with any but the Ollier-Thiersch grafts, it is evident that it must work equally well with the "small deep grafts" from the very fact that the granulations between the grafts will become attached to the single layer of gauze.

Twenty-three cases have been treated by this method which includes those treated by Dr. Jacob Manting. The two cases in which the greatest difficulties and poorest results were encountered are here reported. The remaining twenty-one cases were most satisfactory and practically all the grafts took.

Doctor Manting's case, a man, age thirty-six; a third-degree burn of the left side of the body, involving almost the entire upper extremity, a large burn over the pectoralis major muscle and the outer and posterior aspect of the leg. The grafting was performed in two sittings. The upper extremity and chest at the first, with perfect results. Ten days later the leg was grafted. The patient was a very nervous individual and hard to control. Through his restlessness he injured the grafts, resulting in only 60 per cent. take.

Second case, a boy, age fourteen; a third-degree burn involving one-half of the right thigh and three-fourths of the leg. This burn occurred one year ago. Two attempts to graft the area were previously made resulting in a complete failure. The exuberant granulations were shaved off with a razor under anæsthesia; the base presented dense scar tissue. Wet dressings were applied for two days, after which the entire area was grafted. Practically all the grafts took except an area two inches in diameter on the calf. This failure was attributed to the impaired circulation of the part due to the scar tissue at the base of the granulations. This area was again grafted several months later; the graft took but in a few months an ulcer appeared over the same area.

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OSTEOMA OF THE FRONTAL BONE

Osteomata of the bones of the skull are relatively common, and, unless situated so as to cause symptoms from encroaching upon surrounding structures, are of little moment. Many overlie meningiomas and are really hyperostoses secondary to the underlying tumor. When osteomata occur about the orbit or frontal sinus they may cause serious local disturbances and intracranial complications. This is especially true of ethmoid and frontal sinus osteomata in which their removal becomes imperative. The frontal sinus

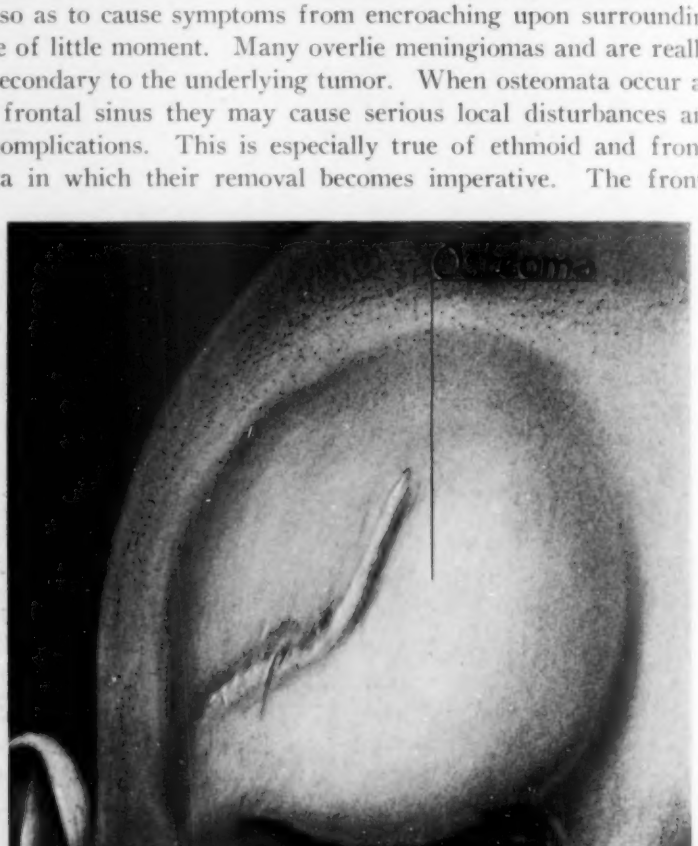

Fig. 1.—Appearance of tumor showing scar of former operation.

and ethmoid osteomata have been discussed fully by Cushing, Armitage, and others. The case I wish to present is of a different type, originating in the frontal bone and later encroaching upon and deforming the orbit and frontal sinus.

Case.—C. H., a school-girl, sixteen years of age, came to me January 29, 1931. Family history, negative. Menses began at fifteen and regular. Always well except attacks of headaches all life. Present illness began about four years ago. Patient came home from school with very severe frontal headache and obtained no relief from medication. A slight elevation on right side of the forehead was noticed for the first time. No soreness or tenderness observed. One week later surgeon chiseled off lump. Headaches relieved until about six months ago when they returned. Previous to this had noticed lump again. Headaches have persisted and very severe past six weeks.

During past six months unable to open right eye completely and eyeball will not turn upwards. Each attack of headache confined patient to bed for two or three days at a time. No visual disturbance except that caused by inability to look upwards with right eye.

Examination revealed a bulging in right frontal region projecting three-fourths of an inch above the surrounding scalp and about two and one-half inches in diameter each way. The supra-orbital ridge was pushed downwards, narrowing the orbital cavity. The bulging and thickening involved the outer two-thirds of the supra-orbital ridge and extended upwards for two and one-half inches. Laterally it extended to within one-half inch of the great wing of the sphenoid and involved the external angular process of the frontal bone. Medially it extended to within one-half inch of the sagittal suture and deformed the lateral wall of the right frontal sinus. There was a scar over the middle of the tumor. (Fig. 1.) The neurological examination revealed right orbit limited in motion upwards to the horizontal position. Ptosis right lid, apparently mechanical and not due to nerve paralysis. Fundi and fields negative. No other changes in the nervous system. X-rays of the head revealed a tumor of the right frontal bone involving the outer part of the orbit and the lower two and one-half inches of the outer part of the frontal bone. (Fig. 2.) The blood Wassermann was negative.

FIG. 2.—Lateral film showing projection of tumor.

Operation under avertin anæsthesia February 3, 1931, All Saints Hospital. A horseshoe flap of scalp was turned downwards. A grayish-colored bone-tumor was revealed. (Fig. 3.) The line of demarcation between tumor and normal bone could be distinctly seen. The tumor was surrounded with trephine openings and the openings connected with the De Vilbiss. The supra-orbital ridge was preserved and the main mass of bony tumor lifted out. The exposed dura was normal, as well as the inner table. The excessive bone production appeared to be limited to the diploe. The inner table was not deformed. The orbital plate was thickened in its anterior part and this portion was removed. The outer shell of the supra-orbital ridge was left as a bridge. (Fig. 4.) All demonstrable tumor tissue was removed with the rongeur and curette. The lateral and frontal walls of the right frontal sinus were removed. The mucous membrane was left intact and would balloon out with each respiration. The flap was replaced, leaving a rather large bone defect. Convalescence was uneventful and the wound healed *per primam*. The headaches have not recurred and there is only slight limitation of motion of the right orbit. The ptosis has partially disappeared.

The growth evidently originated in the frontal bone above the supra-orbital ridge. It gradually extended in all directions until it involved almost the entire supra-orbital ridge, the orbital plate of the frontal bone, the lateral and frontal walls of the right frontal sinus and extended downwards to include the external angular process of the frontal bone. The orbital cavity had been very much narrowed from above downwards so that the orbit was crowded and the upward rotation limited. The most disagreeable

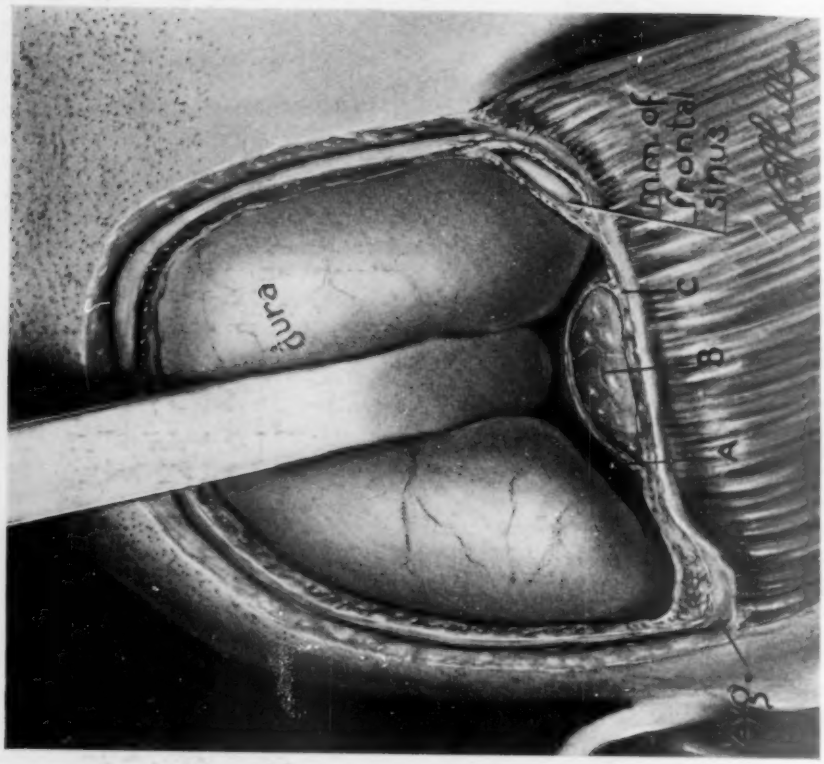

FIG. 4.—Appearance after removal of tumor.

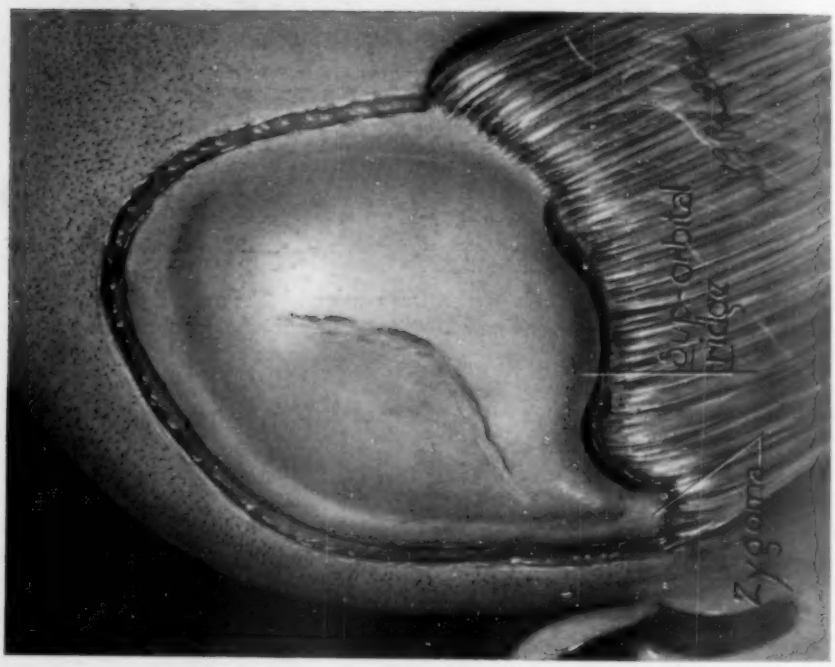

FIG. 3.—Tumor after turning down flap of scalp.

feature was the constant pain. At operation the consistency of the osteoma was softer than normal bone, had a granular appearance and could be removed with a bone curette except the inner and outer tables, which were as hard as normal bone. The microscopical description after decalcification follows. (Dr. Wm. J. McLean, pathologist.) Specimen consists of a portion of frontal bone measuring six by four, five by two centimetres. External surface exhibits an eroded depression two centimetres in diameter. This discoid piece of bone is uniform in consistency and possesses an eburnated type of hardness. Grossly, it is healthy compact bone throughout, except at a superficial eroded

FIG. 5.—Appearance ten days after operation.

area in depression noted above. Cross-sections were taken through bone and decalcified. Microsections show the inner table of circumferential lamellæ to be well preserved. The outer table is roughened and ragged; for the most part it is composed of degenerated sclerotic tissue and partially dissolved fragments of osteoid trabeculæ. The spongy bone or diploe shows neoplastic bone generation. The osteoid trabeculæ are thrown down in a very orderly fashion and the lamellæ are completely differentiated into dense cancellous and compact bone formation. The lacunæ or spaces are filled with a connective-tissue type of osteogenic tissue. Marrow tissue has the appearance of being almost completely smothered out. The osteoblasts are numerous and maintain an orderly arrangement. Capillaries in lacunæ are congested. This picture indicated neoplastic

bone generation of the diffuse type. However, the differentiation into compact and cancellous bone is complete. This may be onsidered a form of neoplastic bone production midway between the benign classical osteomata on the one hand and osteosarcoma on the other. It possesses a tendency towards progressive extension but will not metastasize. *Diagnosis.*—Diffuse osteomatosis. (Virchow.)

The youth of the patient and the comparative rapidity of the growth makes one fear a recurrence, although all demonstrable tumor was removed. This patient would have undoubtedly been beyond surgical relief in another year or two because the tumor was almost beyond surgical accessible regions at the time of operation. Eighteen months have elapsed since the operation with no signs of recurrence and the patient is still free of pain and has almost a normal upward rotation of the orbit. The removal of so large an area left a large bony defect. (Fig. 5.) It is planned to insert a celluloid plate at a later date for cosmetic effect.

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A PRACTICAL APPLICATION OF WOLFF'S LAW AS TO THE INTERNAL STRUCTURE OF BONE *

DURING the past century three very important discoveries have been made in connection with the structure of normal bone under normal conditions of weight bearing and muscle pull and its variation from the normal under abnormal conditions of weight bearing and muscle pull.

During the first part of the nineteenth century, Bourgery, Vard, Vymann, Engel, and others observed the fact that the spongiosa of every part of every normal adult bone has a definite anatomical structure. Thus the

FIG. 1.

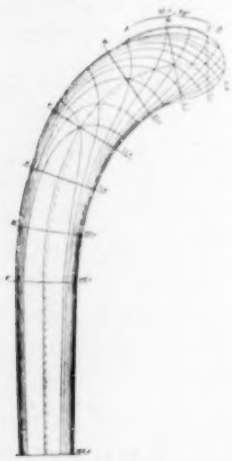

FIG. 2.

trabecular arrangement of all normal adult femora are exactly alike and this is true of all corresponding bones of the human skeleton.

In 1867 the mathematician, Cullman, in studying some anatomical preparations of Herman von Meyers, made the further discovery that: "The course of the trabeculæ of the spongiosa agrees with the so-called stress trajectories of graphical statics."

* Read before the North Central Illinois Medical Association, December 6, 1932.

T[illegible], Figure 1, taken from Hoffa's Lehrbuch der Orthopädischen Chirurgie, represents a sagittal section of the upper end of the femur. Figure 2, taken from the same author, represents a crane shaped like the upper end of a femur, showing the lines of maximum stress and strain to which such a crane would be exposed in supporting the weight of an average torso of say about 150 pounds. A glance at these two figures immediately reveals the fact that the trabeculæ of the femur are arranged exactly as are the lines of major stress and strain in Cullman's drawing, based on his mathematical calculations. In other words, the architecture of the femur is so arranged as to offer the greatest resistance to normal weight bearing and muscle pull by the utilization of the least possible bony material.

Later Wolff discovered the fact that the internal structure of the bone will adjust itself to any new weight-bearing requirements to which it may be exposed. Thus, if a faulty union occurs after a fracture the lines of greatest stress and strain will necessarily be altered and in consequence thereof the trabeculæ rearrange themselves so as to meet the new conditions of stress and strain, just as soon as the limb begins to function with the bone in this abnormal shape. A sagittal section of such a deformed bone will show the trabeculæ arranged differently from a corresponding normal bone.

The following is a literal translation of Wolff's Law as given by Hoffa.

> Just as normal bones possess an internal structure in conformity with the so-called stress trajectories of graphical statics so can the architecture of bones whose forms have undergone changes due to pathological processes be predicted with mathematical certainty.

The foregoing is a recapitulation of generally known and universally accepted facts in regard to the internal structure of normal bone and of the changes which occur in the internal structure of a bone when the stresses and strains to which it is subjected vary from the normal.

My object in briefly restating these facts is to show their relation to an observation I made some time ago in reference to the internal structure of the upper end of a femur during the healing process of a fracture of the hip. Not only is this observation of scientific interest but of real practical value because it gives us a hint as to the best method of treating such fractures. Several years ago I saw a sagittal section of the upper end of a femur in which a fracture of the neck had occurred about six months previously and which had been treated by the Whitman method. The thing that attracted my attention immediately was the fact that the trabeculæ were not deposited normally but instead were arranged criss-cross and in every possible plane. Previously, in examining X-ray plates of cases treated by the Maxwell-Ruth method this abnormal arrangement of the trabeculæ had not attracted my attention. In going back to the X-ray plates of the cases treated by the Maxwell-Ruth method and inspecting them more critically, I made the observation that in each instance examined I found the trabeculæ all laid down normally.

A number of case histories could be given and the röntgenograms could be exhibited to illustrate the above statement but it seems more desirable to give one case in detail particularly as we were able to secure a number of excellent stereopticon films which show the trabeculation with unusual clearness.

Mr. C. C., Case 20145, a well-developed male, aged thirty-nine, was admitted to the service of my associate, Dr. A. T. Lundgren, at the Augustana hospital January 26, 1930, with a mesial fracture of the anatomical neck of the femur. Twelve hours after admission the fracture was reduced and put up according to the Maxwell-Ruth method of extension and internal rotation. Stereopticon films taken March 15 show the fragments in fair apposition. April 5, or ten weeks after the fracture had occurred, stereopticon films were again taken and Doctor Beilin, the röntgenologist, made the following report:

Stereoscopic films taken of the left hip region reveal that the line of fracture is considerably obliterated and is occupied by new bone formation. There is no marked irregular distortion of the trabeculæ at the site of fracture, which indicates that the lamellæ of new bone are considerably laid down in their normal direction and plan. The shaft is only slightly displaced upward, approximately one-half inch.

Radiographically the findings are consistent with union at the left hip region. The marked absence of irregular distortion of the bone grain at the site of fracture indicates that the lamellæ of new bone which were laid down are consistent with the normal pattern of architecture.

At this time the extension was removed and the following day a plaster-of-Paris spica was applied from the umbilicus to an inch above the left knee. Three days later the patient was allowed to walk with crutches and with a high sole on the good foot. Discharged from hospital eleven weeks after admission. July 19, or twenty-five weeks after the fracture occurred, the spica and high sole were removed and the patient allowed to walk with a cane. On that date following notation was made: July 19, 1930, patient lying flat on back, both lower extremities lying on table apparently exactly alike. No eversion of either foot. Right anterior superior spine to right internal malleolus 38½ inches. Left anterior superior spine to left internal malleolus 38 inches. Left knee flexes to 95 degrees passively and to 90 degrees actively. Thigh flexed on abdomen to 135 degrees. Abduction 45 degrees.

This case is typical of all the cases treated by this method and is reported because it illustrates the fact that if a fracture extremity is placed in as nearly normal a condition as to weight bearing and muscle pull as is possible under the circumstances the bone salts will be deposited correctly in the first instance, thus saving the necessity of reabsorption and redeposition. That this will save much energy, time, and expense to the patient must be self evident. In addition it will almost surely prevent ununiting fractures, one of the most common and distressing complications of fractures of the hip.

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